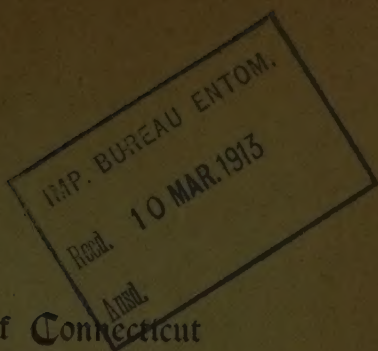




State of Connecticut

REPORT

OF

The Connecticut Agricultural
Experiment Station

FOR THE YEAR 1907

PART V

SEVENTH REPORT OF THE STATE ENTOMOLOGIST

W. E. BRITTON, Ph.D.

SEVENTH REPORT
OF THE
STATE ENTOMOLOGIST
OF
CONNECTICUT
FOR THE YEAR 1907

BY
W. E. BRITTON, PH.D.
State Entomologist

New Haven, Conn.
1908

PART V.

SEVENTH REPORT

OF THE

STATE ENTOMOLOGIST OF CONNECTICUT

To the Director and Board of Control of the Connecticut Agricultural Experiment Station:

I hereby transmit my seventh report as state entomologist, according to Section 4387 of the General Statutes. As all state reports are to be published biennially hereafter instead of annually, technically this is Part V. of the biennial report. The financial and other administrative details are herein omitted, but will be published at the end of the biennial period.

Respectfully submitted,

W. E. BRITTON,

State Entomologist.

During the calendar year of 1907 the members of the office force have made thirty-one nursery inspections, thirty-one inspections of orchards, gardens and greenhouses, have written 1,156 letters regarding matters pertaining to the work of the department, sent out sixty-eight packages by mail and express, and have given eight addresses and lectures at agricultural and scientific meetings.

The state entomologist has been ably assisted throughout the year by Mr. B. H. Walden as general assistant, who has been in charge of the office in the absence of the entomologist; by Mr. George H. Hollister as local superintendent in charge of gypsy moth work at Stonington; and by Miss Elizabeth B. Whittlesey, who has worked as stenographer for half of each day.

ENTOMOLOGICAL FEATURES OF 1907.

Entomologically, the most interesting feature of the season was the outbreak of the peach sawfly in an orchard at Yalesville. This insect proved to be a new species, which has been described as *Pamphilius persicum* by Dr. A. D. MacGillivray, and was so abundant as to threaten the defoliation of a large number of trees. Consequently the owners sprayed between four and five thousand trees with lead arsenate, with satisfactory results. Mr. Walden has made a careful study of this insect, an account of which appears elsewhere in this report.

Good progress has been made in controlling the gypsy moth, which was discovered in Stonington last year. (See Report for 1906, p. 235.) Over 13,000 trees were banded in 1907 as against 1,300 the previous season, and though twice as many men were employed and much scouting done, only 2,936 caterpillars were found in 1907 where 10,000 were taken in 1906. The work was also strengthened and supported by an act of the legislature giving authority and making an appropriation. This entire matter is treated in detail on another page of this report.

The fall canker worm, *Anisopteryx pometaria* Harris, was more abundant at the station than since 1900, and the large number of males clustering on the trunks of trees on warm days in November and December indicate that this species will be even more abundant and destructive in 1908.

The spiny elm caterpillar, *Euvanessa antiopa* Linn., and the apple leaf miner, *Tischeria malifoliella* Clem., which were so common in 1906, did little damage in 1907.

The apple aphid, *Aphis pomi* DeGeer, was quite injurious, especially to nursery and newly set orchard trees, and in several cases spraying was necessary to prevent a marked checking of the growth.

The hickory tussock moth, *Halisidota caryae* Harris, was more abundant than for several years, and the caterpillars were found feeding upon apple, hickory and a number of other trees. A separate illustrated article treating of this insect is printed on a later page of this report.

In spite of an extreme drought extending through July and August, mosquitoes were exceedingly abundant and annoying in certain localities, and many complaints were received regarding them. In compliance with a request, the region about Niantic

and Crescent Beach was examined for breeding places, and the report is published on a subsequent page of this pamphlet.

The grape vine flea beetle, *Haltica chalybea* Ill., was received from several localities, where it was reported as eating holes in the buds of the grape vine before the leaves unfold.

The winter of 1906-1907 was more severe than the preceding winter, consequently a smaller proportion of San José scales survived. While the increase and spread of this insect was less marked than in 1906, nevertheless it multiplied rapidly late in the season of 1907.

NURSERY INSPECTION.

This work was commenced the first week in September and was nearly completed November 1st, the last inspection being made November 8th. The inspections were made by Messrs. Britton, Walden and Hollister, Mr. Hollister being taken from the gypsy moth work for two months for this purpose. Including one spring inspection, thirty-seven nurseries have been inspected and thirty-six certificates granted during the calendar year. Five firms have gone out of business and four new nurseries have been started. On the whole, the nurseries were in better condition than last season, and much less stock had to be destroyed on account of scale. Many nurseries, however, are curtailing their supply of fruit trees and are growing more and more ornamental stock of such kinds as are not affected by scale. There is also a decided change for the better in the care given the nursery stock by the owners, though a few nurserymen are still careless. A few years ago it was not considered practicable to spray any nursery stock; usually the owners preferred to destroy it. Several nurserymen, following our directions, during 1906 to 1907 have sprayed their growing stock as a measure of safety, using either lime and sulphur or one of the miscible oils. The results have been very satisfactory, it being certain that a much greater degree of infestation would have occurred on untreated stock. The miscible oils are especially convenient for this purpose and do not discolor the trees.

A bill was introduced into the legislature providing for slight changes in the insect pest law, but the matter was opposed at a hearing before the agricultural committee, which reported adversely upon it. The law therefore remains as before.

The nursery firms receiving certificates in 1907 are as follows:

LIST OF NURSERY FIRMS IN CONNECTICUT RECEIVING CERTIFICATES IN 1907.

Name of Firm.	Location.	Inspection Finished.	Certificate Number.
Atwater, C. W.	Collinsville	Oct. 2,	254
Barnes Bros. Nursery Co.	Yalesville	Oct. 14,	263
Beattie, William H.	New Haven	Oct. 4,	257
Bowditch, J. H.	Pomfret Center	Oct. 18,	267
Brainard, Chester F.	Thompsonville	Sept. 14,	249
Burr & Co., C. R.	Manchester	Oct. 9,	260
Comstock & Lyon	Norwalk	Nov. 6,	278
Conine Nursery Co., The F. E.	Stfatford	Sept. 26,	251
Conn. Agricultural College	Storrs	Oct. 29,	274
Conway, W. B.	New Haven	Oct. 5,	258
Dehn & Bertolf	Greenwich	Oct. 17,	265
East Rock Park Nursery	New Haven	Oct. 4,	256
Elizabeth Park Nursery	Hartford	Nov. 13,	280
Elm City Nursery Co.	New Haven	Sept. 9,	247
Gardner's Nurseries	Cromwell	Nov. 19,	279
Gurney & Co., H. H.	New Canaan	Oct. 11,	261
Hale, J. H.	So. Glastonbury	Oct. 23,	270
Holcomb, Irving	Granby	Oct. 24,	271
Houston & Sons, J. R.	Mansfield Depot	Oct. 29,	275
Hoyt's Sons Co., Stephen	New Canaan	Oct. 11,	262
Hubbard & Co., Paul M.	Bristol	Oct. 17,	266
Hunt & Co., W. W.	Hartford	Nov. 1,	276
Kelsey & Sons, David S.	West Hartford	Sept. 28,	253
Keney Park Nursery	Hartford	Nov. 13,	281
Malone, Geo. W.	Highwood	Sept. 26,	250
Norton, A. F.	New Britain	Oct. 25,	273
Pierson, A. N.	Cromwell	Oct. 7,	259
Platt Co., The Frank S.	New Haven	Sept. 28,	252
Purinton, C. O.	Hartford	Nov. 5,	277
Ryther, O. E.	Norwich	Oct. 25,	272
Scott, J. W.	Hartford	Oct. 15,	264
Sierman, C. H.	Hartford	Oct. 4,	255
Vidbourne & Co., J.	Hartford	Sept. 10,	248
Woodruff, C. V.	Orange	Oct. 23,	268
Woodruff & Sons, S. D.	Orange	Oct. 23,	269

TESTS OF VARIOUS GASES FOR FUMIGATING NURSERY TREES TO DESTROY SAN JOSÉ SCALE.*

The object of the tests herein described was to ascertain if there is any gas that can be used more conveniently than hydrocyanic acid gas, especially in fumigating small lots of trees, cions and budsticks. For this purpose the materials must be reasonably inexpensive, the gases easy to generate, the apparatus simple, and the operation comparatively free from danger to the operator as well as harmless to the trees.

The writer was assisted in the chemical part of this work by Mr. F. H. Heath, a graduate student in chemistry in Yale University; and by Mr. B. H. Walden, who did most of the fumigating work.

Some orchardists and nurserymen are considerably prejudiced against fumigating trees with hydrocyanic acid gas. This prejudice is not well-founded though it must be admitted that many trees have been injured by leaving them too long in the fumigating house, and by attempting to fumigate them when wet. When properly done according to the methods usually recommended, no injury results. This has been proven over and over again, not only in our own experiments, but also in the tests made by other entomologists.

In a large fruit nursery where most of the stock is dug in the fall and not sent out until the following spring, it is an easy matter to fumigate the stock before heeling it in on the grounds. But it often happens that a customer calls for two or three trees which have not been dug or fumigated. The nurseryman dislikes to turn away a customer, and if possible will furnish the stock desired. Of course each well-equipped nursery should have small fumigating boxes in which a few trees or shrubs can be treated, in addition to the large fumigating house. But most of them have only the large house, and it is very expensive to charge it with gas for only a few trees. Some of the small

* A brief abstract of this paper was given at the meeting of Economic Entomologists at Chicago, December 27-28, 1907, and will be published in the *Journal of Economic Entomology*.

nurseries are not provided with any sort of fumigating house. It is rather difficult for the average nurseryman to weight out the small quantity of cyanide necessary to use in a small box because he is not equipped with sensitive scales or balances for the purpose. If some volatile liquid could be used that he could measure in a glass cylinder, it would obviously be a much more simple and convenient matter.

For the purpose we therefore selected carbon disulphide and carbon tetrachloride for volatile liquids, and sulphuretted hydrogen and chlorine for gases generated by chemical action. In order to make comparisons, a few tests were made with hydrocyanic acid gas, and untreated trees were kept as checks.

The trees were fumigated in a long narrow box containing ten cubic feet of space. In order to ensure a more uniform distribution of the gas, two generating dishes were used, one being placed near each end. The liquids were volatilized in shallow pans placed upon crossboards near the top of the box and above the trees. For the other materials deeper generators were necessary, and ordinary pudding dishes served the purpose nicely. A piece of glass was set in each end of the cover so that the action of the materials in the generating jars could be watched from outside.

As some of these materials were being used in this work for the first time, no data were available as a basis from which to compute quantities. In some cases Mr. Heath figured out the quantities of chemicals necessary to generate a volume of gas sufficient to fill the box if all the air was displaced. We could then divide these amounts by two or by four, as seemed best.

With carbon disulphide we had, of course, Smith's* and Garman's† experiments in destroying the melon aphid and the experiments of various entomologists in fumigating stored grains to guide us. The writer once purchased some plants of red-twig dogwood for the garden, and when delivered at the house they were found to be slightly infested with San José scale. The plants were placed in one of the set laundry tubs in the cellar, an unmeasured quantity of carbon disulphide poured in, and the whole tightly covered for about twenty-four hours.

* New Jersey Agricultural Experiment Station Bull. 109, p. 32, 1895, and 121, p. 11, 1897.

† Kentucky Agricultural Experiment Station Bull. 53, p. 144, 1894.

The plants were then set in the garden, grew well, and showed no sign of scale during the season, or of injury from the treatment. However, with some of the gases it was necessary to guess at the quantities, but we sought to kill the scale, and expected that many of the trees might be injured. I am now convinced that further tests with some of the gases, especially carbon tetrachloride, in smaller quantities are desirable.

Baldwin apple and peach of several standard varieties were the trees used. All were more or less infested with San José scale, though none so badly as to seriously affect their vitality. Both roots and tops were fumigated, the trees properly labeled and planted in nursery rows on the station grounds, where they could be watched during the season. In all 359 trees were treated. The following table shows the number treated by each kind of gas:

	Apple	Peach
Carbon disulphide	59	61
Carbon tetrachloride	47	60
Sulphuretted hydrogen	10	15
Chlorine	25	22
Hydrocyanic acid gas	20	40
Total	161	198

The details of each test, with results, are given in the following descriptions and tables.

VOLATILE LIQUIDS.

Carbon Disulphide.

Carbon disulphide (CS_2) is a heavy liquid having a specific gravity of 1.29 and a boiling point of 115°F . The vapor is inflammable, and ignites in air at about 300°F . It is 2.63 times as heavy as atmospheric air, and one volume of the liquid evaporates to make about 375 volumes of vapor. Pure carbon disulphide is colorless and has no unpleasant odor, but the commercial article has a yellowish color and an extremely disagreeable odor, both of which are due to impurities which enhance its poisonous qualities.* The price varies from fifteen to twenty cents per pound, but it is cheaper in large quantities.

* Farmers' Bulletin 145, U. S. Dept. of Agr., Washington, D. C., 1902.

Preliminary tests showed us that this liquid does not volatilize very readily at ordinary temperatures. Where large quantities are used this is quite a serious objection, as it not only requires a long fumigation period, but there is less certainty regarding the period in which the effect of the full amount of material is acting upon the scale and upon the trees. If trees with naked roots are exposed for too long injury will result from drying. It was suggested that this difficulty might be obviated by volatilizing the liquid in heated pans. Therefore heavy cast iron stew pans or "spiders" were used as generating dishes, these holding the heat much longer than thin ones stamped out of sheet steel. After heating to nearly 200° Fahr. one was placed near each end of the box above the trees. Small holes through the cover of the box enabled us to pour the liquid through a funnel directly into the heated dish. The holes were stopped with corks, and the carbon disulphide, which could be observed through the glass in the cover, volatilized in a few seconds or minutes, according to the quantity. Without the heated dishes, several hours were necessary in some cases. The quantities of materials used, length of fumigating period, and the effect upon scales and trees are given in Table I.

Results with Carbon Disulphide.

The smallest quantity used (10 fluid ounces per 100 cubic feet) did not kill all of the scales in a fumigation period of one hour. Where the heated dish was used to volatilize the liquid, 4.3 per cent. of the scales survived the treatment. Where the dish was not heated 19.2 per cent. came through alive, but one-third of the carbon disulphide was left in the dish at the end of the hour, so that much less of the vapor really acted upon the scales. All scales were killed in each of the other tests. It is to be regretted that this small quantity of disulphide was not given a two-hour period in one or more tests. One tree in Experiment No. 3 failed to grow, but this probably has little connection with the fumigation, as no other trees were injured until they were given three times the amount of liquid and four times as long a fumigation period. Moreover, untreated trees often die when transplanted. When the liquid equalled or exceeded thirty fluid ounces for one hour, some of the trees were

TABLE I.—CARBON DISULPHIDE.

No. Expt.	Fluid ounces of liquid used for 100 cu. feet.	Fumigating Period.	Number of Generating dishes.	Number of trees.		Effect on Scales.			Effect on trees.		Remarks.
				Apple.	Peach.	Alive.	Dead.	Percent Alive.	Alive.	Dead.	
3	10 fluid oz.	1 hour	1 heated dish	5	5	4	87	4.3	9	1	Peaches looking good. 4 apples looking good, 1 started but died back.
7	10 "	1 "	1 unheat'd dish*	5	5	23	96	19.2	10		All trees making fair growth.
5	20 "	1 "	1 heated dish	5	5	0	all	0	10		"
8	30 "	1 "	1 "	5	5	0	"	0	10		"
9	30 "	2 "	1 "	5	5	0	"	0	10		Peaches made good growth. 3 apples looking good, 2 died back considerably at tops.
12	30 "	4 "	1 "	5	5	0	"	0	8	2	4 peaches died back considerably at tops.
13	60 "	3 "	2 "	5	5	0	"	0	3	7	1 apple 4 looking good. 4 peaches with poor growth, 1 dead. 2 apples " " " 1 "
14	40 "	2 "	2 "	4	5	0	"	0	8	1	1 peach making good growth, 4 dead. 2 apples with poor growth, 3 dead.
15	60 "	2 "	2 "	5	5	0	"	0	5	5	1 peach made good growth, 3 started low, 1 dead. 4 apples made fair growth. 4 peaches dead, 1 with poor sprout. 1 apple dead, 3 started low, 1 with weak sprout.
16	80 "	2 "	2 "	5	4	0	"	0	2	7	2 peaches made fair growth.
29	40 "	4 "	2 "	5	7	0	"	0		12	All trees dead.
31	40 "	3 "	2 "	5	5	0	"	0		10	" " "

* About $\frac{1}{3}$ of liquid left in dish.

injured, and in some cases forty ounces for two hours killed all of the trees, though in other instances some trees survived even a larger quantity. It is quite possible that a longer period with the smallest quantity would have given satisfactory results.

Carbon Tetrachloride.

Carbon tetrachloride (CCl_4) is a clear, colorless liquid having a specific gravity of 1.63 and a boiling point of 169°F . It has a pleasant odor somewhat resembling that of chloroform, and its vapor is non-inflammable and less poisonous than that of carbon disulphide. Carbon tetrachloride is used chiefly as a solvent and costs about forty cents per pound, though in quantities it can be purchased at a much lower price. Heated pans were used to volatilize this gas, and the quantities used, fumigation period, and results are shown in Table II.

Results with Carbon Tetrachloride.

As carbon tetrachloride killed all of the scales in each of the tests made, it is probable that even smaller quantities would have answered quite as well. At the rate of forty fluid ounces per 100 cubic feet of space for two hours, some of the trees failed to grow, and all larger quantities produced similar results. Thirty fluid ounces appears to be about the maximum limit of safety, and further trials should be made with smaller quantities of liquid and shorter periods of fumigation. As regards convenience, this material is very promising, as it is not dangerously poisonous to breathe in small quantities nor liable to explode, though more expensive than carbon disulphide.

GASES GENERATED BY CHEMICAL ACTION.

Sulphuretted Hydrogen.

Sulphuretted hydrogen or hydrogen sulphide (H_2S) is an invisible gas generated in our experiments from iron sulphide and sulphuric acid. It is 1.19 times heavier than air. It has a disagreeable and distinctive odor, and is very poisonous, although on account of the odor its presence can be detected at once. Sulphuretted hydrogen is given off from spoiled eggs, and to some extent from the lime and sulphur mixture.

The sulphide of iron used is in the form of hard lumps made by crushing the fused mass or slag. It is quite porous, which facilitates the generation of the gas. It should be crushed fine before use. Iron sulphide costs from eight to ten cents per pound.

Commercial sulphuric acid contains about ten per cent. of water, and costs about five cents per pound in nine pound bottles. Complete data regarding the tests with this gas appear in Table III.

Results with Sulphuretted Hydrogen.

All scales were killed by this gas and some of the trees receiving the largest and smallest quantities died, though for some inexplicable reason an intermediate amount produced no injury. The method of generating this gas is too slow to render it a convenient fumigating agent, even if it did not injure the trees. Possibly some easier and more satisfactory arrangement could be devised.

Chlorine.

Chlorine (Cl) is a heavy greenish gas with a pungent odor, and is not only poisonous but extremely irritating to the mucous membrane. It is about 2.5 times heavier than air, and is prepared by treating ordinary chloride of lime or bleaching powder with commercial sulphuric acid. Bleaching powder costs about five cents per pound.

Table IV. presents all of the statistics connected with the chlorine tests.

Results with Chlorine Gas.

As perhaps might be expected with chlorine, all of the scales were killed and most of the trees died also. This gas is altogether too inconvenient, too disagreeable and too destructive to trees to be of any value in fumigating work. A peculiar effect was noticed on those trees which survived the treatment. Nearly all buds were killed, and the bark was injured and discolored for half an inch or so each way from the bud, as if the gas entered through the bud and damaged the surrounding wood. The discoloration was apparent in some cases when the trees were removed from the fumigating box.

TABLE III.—SULPHURETTED HYDROGEN.

Expt. No.	Quantity of Materials for 100 cubic feet.	Fumigat- ing period.	Number of Generating dishes.	Number of trees.		Effect on Scales.				Effect on trees.		Remarks.
				Apple.	Peach.	Alive.	Dead.	Percent. Alive.	Alive.	Dead.		
1	25.1 lbs. 260 fl. oz. Sul. Acid 170 " Water	1 hour	1 dish	0	5	0	all	0	2	3	2 made fair growth.	
2	12.5 lbs. 170 fl. oz. Sul. Acid 70 " Water	1 "	2 "	5	5	0	"	0	10		All making fair growth.	
4	5 lbs. 80 fl. oz. Sul. Acid 50 " Water	1 "	2 "	5	5	0	"	0	8	2	Peaches looking fair. 2 apples looking fair, 1 with poor growth, 2 dead.	

TABLE IV.—CHLORINE GAS.

Expt. No.	Quantity of Materials for 100 cubic feet.	Fumigating Period.	Number of Generating dishes.	Number of trees.		Effect on Scales.				Effect on trees.		Remarks.
				Apple.	Peach.	Alive.	Dead.	Per cent. Alive.	Alive.	Dead.		
21	17.2 lbs. 125 fl. oz. Sul. Acid 500 " Water	1 hour	2 dishes	5	5	0	all	0	7	3	2 peaches with good sprouts, 3 dead.	
22	8.6 lbs. 62.50 fl. oz. Sul. Acid 250 " Water	1 "	2 "	5	2 Jap. Plums	0	"	0	8	2	2 peaches making good growth. 2 plums making good growth. 3 apples looking poor, 2 dead.	
24	17.2 lbs. 125 fl. oz. Sul. Acid 500 " Water	2 "	2 "	5	5	0	"	0		10	All died.	
23	34.4 lbs. 250 fl. oz. Sul. Acid 1000 " Water	2 "	2 "	5	5	0	"	0		10	All died.	
26	8.6 lbs. 170 fl. oz. Sul. Acid 670 " Water	2 "	2 "	5	5	0	"	0		10	All died.	

Hydrocyanic Acid Gas.

Hydrocyanic acid is a colorless gas (HCN) and one of the most poisonous gases known. It has the odor and taste of prussic acid or bitter almonds. It is lighter than air, and is generated by adding water and sulphuric acid to potassium cyanide in about the following proportions:

Potassium cyanide	1 ounce
Sulphuric acid	2 fluid ounces
Water	4 " "

The quantities named have been determined by experiment to be suitable for one hundred cubic feet of space in fumigating dormant nursery trees. As potassium cyanide is often adulterated with sodium cyanide or with common salt (sodium chloride), only the best grade (98-99 per cent.) and the best commercial sulphuric acid should be used. The value of the tests with this gas is for purposes of comparison, and yet it also shows that nursery stock is not injured by it when properly fumigated. The results are given in Table V.

Results with Hydrocyanic Acid Gas.

All scales were destroyed and no trees were injured except in two lots one from each died, but there is no indication that they were killed by the gas. One point to be noted is that in Experiment No. 30 the trees were given the same quantity of cyanide commonly used for fumigating nursery stock (one ounce per 100 cubic feet) and twice the period. The trees were sprinkled thoroughly by means of a watering pot,—but none were injured by this fumigation. It should also be noted that twice the usual quantity for four times the usual period, and that three times the usual quantity for one-half hour (the usual period) caused no injury to the trees.

GENERAL REMARKS.

These tests are preliminary and conclusions based upon them are scarcely warranted. Yet they indicate the desirability of making further tests with smaller quantities of carbon tetrachloride and with longer fumigating periods with the small amounts of carbon disulphide. Possibly it will appear that one or both of these liquids are suited for fumigating small lots

TABLE V.—HYDROCYANIC ACID GAS.

Expt. No.	Quantity of Materials for 100 cubic feet.	Fumigat- ing Period.	Number of Generating dishes.	Number of trees.			Effect on Scales.			Effect on trees.		Remarks.
				Apple.	Peach.		Alive.	Dead.	Per cent. Alive.	Alive.	Dead.	
32	1 oz. Cyanide	½ hour	2 dishes	5	5		0	all	0	9	1	4 peaches made good growth, 1 started below bud. 4 apples made good growth, 1 died after starting.
33	1 oz. "	1 "	2 "	5	5		0	"	0	10		All trees made fair growth.
25	1 oz. "	2 "	2 "	0	10		0	"	0	9	1	8 made good growth, 1 started below bud, 1 dead.
34	2 oz. "	2 "	2 "	5	5		0	"	0	10		All trees made good growth.
36	2 oz. "	½ "	2 "	5	5		0	"	0	10		" "
27	3 oz. "	½ "	2 "	0	10		0	"	0	10		8 made good growth, 2 made but little growth.

* Trees wet when fumigated.

of nursery stock, but at present we cannot do better than to use hydrocyanic acid gas in the same way as has been recommended. Care should be taken to do it properly, and the growth should be well ripened if treated in the fall.

It should also be noted that in many instances the apple trees were fully as susceptible to injury from the gases as peach trees. This is contrary to the belief of most nurserymen.

SPRAYING TESTS WITH COMMERCIAL "SOLUBLE OILS" TO KILL THE SAN JOSÉ SCALE.

BY W. E. BRITTON AND B. H. WALDEN.

Spraying tests with "soluble" or miscible oils were made on a few trees in 1907. On account of gypsy moth work, which required a large part of the funds, at our disposal as well as nearly all of our time, it was impossible to devote much attention to spraying experiments. However, over two hundred young apple trees were treated with the three best-known commercial "soluble" oils on the market,—"Scalecide," "Target Brand Scale Destroyer," and "Kill-o-Scale." These substances are similar in composition and method of application except that Kill-o-Scale contains an addition of sulphur, while the others do not.

All the trees sprayed were apple trees except two Japan plums, and were portions of the orchards of A. E. Plant of Branford and E. M. Ives of Meriden. As the spring of 1907 was very late, the buds did not open until about the first of May. At Branford the spray was applied April 30th, and at Meriden, May 1st.

The tests show that all three products were about equally effective when used in the proportions of one part to fifteen parts of water. Very few scales survived the treatment in any case. The following tables give the statistics regarding these trials:

In addition to the tests recorded in the tables, all of the fruit trees on the station grounds were sprayed with "Scalecide," one part to fifteen parts of water, in the fall of 1906. When examined on March 29th very few living scales could be found. Mr. Ives also sprayed nearly all of his orchard of several

TABLE VI.—EXPERIMENTS AT BRANFORD, APRIL 30, 1907.

Kind of trees.	Number of trees treated.	Condition of trees before treatment.	Materials applied.	Out of 100 Scales on Twigs—			Percentage efficiency of treatment.
				Winter killed.	Killed by treatment.	Alive after treatment.	
Apple	33	Moderately infested.	{ 1 gal. Target Brand Scale Destroyer. 15 galls. water.	51.9	43.8	4.3	95.7
Apple	18	Moderately infested.	{ 1 gal. Kill-o-scale. 15 galls. water.	60.	39.99	.01	99.99
Apple	57	Moderately infested.	{ 1 gal. Scalecide. 15 galls. water.	56.	43.8	.2	99.8
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TABLE VII.—EXPERIMENTS AT MERIDEN, MAY 1, 1907.

Kind of trees.	Number of trees treated.	Condition of trees before treatment.	Materials applied.	Out of 100 Scales on Twigs—			Percentage efficiency of treatment.
				Killed by winter and by fall spraying.	Killed by treatment.	Alive after treatment.	
Apple	30	Badly infested. Sprayed in fall.	{ 1 gal. Target Brand Scale Destroyer. 15 galls. water.	91.3	8.7	0.	100.
Apple	22	Badly infested. Sprayed in fall.	{ 1 gal. Kill-o-scale. 15 galls. water.	97.7	2.29	.01	99.99
Japan Plum	2	Badly infested. Sprayed in fall.	{ 1 gal. Kill-o-scale. 15 galls. water.	93.7	4.8	1.5	98.5
Apple	60 — 114	Badly infested. Sprayed in fall.	{ 1 gal. Scalecide. 15 galls. water.	88.4	11.6	0.	100.

hundred trees with "Scalecide." The results were satisfactory. At Mr. Plant's orchard about seven hundred trees besides those recorded in the tables were sprayed with "Scalecide" by the owners, and the scale was kept well in check by the treatment.

A few words of caution should here be given for the benefit of those who use the "soluble oils." The contents of the original package should always be shaken or stirred so as to become thoroughly uniform before any is mixed with water. Directions to this effect are sent out by the manufacturers, and in some cases accompany each package. These directions should be followed. If such precautions are taken there will probably be no injury to trees from the use of "soluble" oils. If not thoroughly mixed, however, there is a slight separation of the ingredients, and the oil from the top of the barrel or can will not mix well with water and may cause injury to the tree. A large tree sprayed with one of these preparations not properly stirred was injured by having all the leaf and blossom buds killed on certain branches, which did not put out leaves until the other branches were in full leaf. Adventitious buds appeared, and later the tree was uniform in foliage. Sometimes after long standing it is necessary to add a small quantity of water and incorporate it with the oil before it will mix properly with the larger amount of water used at the time of applying it to the trees.

THE PEACH SAWFLY.

Pamphilius persicum MacGillivray.

A NEW ENEMY OF THE PEACH ORCHARD.

By B. H. WALDEN.

The peach orchard of Barnes Brothers at Yalesville, Conn., was visited at the request of the owners on June 14, 1906, to look at some insects that were flying around among the trees. Many trees in this section had been partially defoliated the previous season, and while the insects were not observed by the owners at that time, the occurrence of an unfamiliar insect in numbers in the same locality the following season at once suggested the cause. The insect proved to be a four-winged fly about three-eighths of an inch long, the head and thorax black with yellow markings, the legs and abdomen reddish brown or

brown ocher in color. At this time only six or eight were seen flying around each tree in the infested locality, but Mr. Barnes informed me that they had been very numerous a few days earlier. Upon examining the trees, numerous white eggs were found on the under side of the peach leaves, and some of these eggs were beginning to hatch. The number of eggs observed at once suggested that the insect might prove to be quite a pest.

Material was collected to rear, but while the writer was absent from the station in connection with other work, all specimens died. The next visit was made to the orchard July 27th, when all the larvae had disappeared. A number of trees had been badly defoliated, and evidences of the work of the insect were seen over a considerable area in the orchard. Observations made on this insect during the past season are presented in the following pages.

IDENTITY OF THE PEST.

This insect promised to be interesting even before we saw it, as there are comparatively few insects that feed upon peach foliage. The specimens were sawflies, hymenopterous insects, belonging to the family *Tenthredinidae* (a familiar example of which is the common currant worm). They are called sawflies because the ovipositor of the female consists of a pair of plates with serrated edges, with which some of the species "saw" into the tissues of plants, where they deposit their eggs. Specimens were sent to Dr. A. D. MacGillivray of Cornell University, a specialist in this group, who pronounced it a new species and described the insect as *Pamphilius persicum*.*

Another sawfly, *Selandria obsoletum* Nort., has been reported by Prof. H. A. Morgan,† as seriously defoliating peach and plum trees in Louisiana, in an article giving a description of the insect and its work.

INJURY TO TREES.

The peach sawfly feeds upon the foliage and the injury depends of course upon the extent to which a tree is defoliated. In 1906 many trees in one section of the orchard were quite badly defoliated (see Plate VI, b.), and while surrounding trees

* Canadian Entomologist, Vol. XXXIX, p. 308, 1907.

† La. Expt. Station Bull. 48 Second Series, p. 142, 1897.

showed some damage it was not noticed in another neighboring orchard, thus indicating that the insect was quite local in its work. This year it was more widely distributed, being found in all of Barnes Brothers' orchards, and appeared less local in its movements, though this feature could not be definitely observed, as the badly infested locality of the previous season was all thoroughly sprayed this year. In the orchards of Messrs. Hopson, Hall and Lyman the work of the insect was observed over considerable areas, but was nowhere serious.

The work of the insect is very characteristic, and is first noticed by the rolling of the leaves and later by their shredded appearance as shown on Plate I. This is more fully described under habits of the insect.

FOOD PLANTS.

This sawfly seems to be confined almost entirely to the peach. The foliage of the native trees and plants in the vicinity of the peach orchards, especially those belonging to the rose family, was carefully examined. The only plant found on which eggs had been laid and larvae were feeding was a small bush of the wild black cherry, *Prunus serotina* Ehrh. This was in an old division wall between two portions of the orchards in the badly infested locality. Other black cherries in the vicinity of the orchards were examined but no eggs or larvae were found on them. Many adults were seen resting on the leaves of apple trees, a number of which were in the peach orchard, but no eggs were found on them. On Japanese plums and sour cherries near the infested orchards no trace of the insect was found. In one of the breeding cages, where there was no chance to oviposit on peach foliage, a few eggs were laid on common sorrel, *Rumex acetosella* Linn.

These observations are contrary to the usual habits of native insects that become serious pests. Ordinarily the species will be found feeding on a number of closely allied wild plants, and gradually begins to work on cultivated species, the injury increasing from year to year. A new pest suddenly breaking out in numbers and confining its work to a single cultivated plant, as the peach sawfly is apparently doing, strongly suggests its being an introduced species. In regard to the peach sawfly it is certainly hard to answer the question,—where did they all come from?

ABUNDANCE.

From the examination made in the summer of 1906 it was evident that the insect must have been very numerous over quite a section in part of the orchard. They were the most abundant in this section during 1907. A few notes were made regarding the number of larvae and adults, as follows:

On May 15th a shovelful of earth examined contained *forty-six* larvae. The hole at the greatest diameter measured ten by eleven inches, and five and one-half inches deep at the deepest point. It was two feet ten inches from the nearest tree. This was the first shovelful examined, taken up at random at least two hundred feet from where the insect was found to be the thickest the previous year. The photograph of the holes where adults had emerged (Plate IV), was taken in the same vicinity, the particular spot not being selected on account of the large number of holes, but because it was level and free from rubbish, and is a fair record of conditions on between two and three acres. This photograph was taken natural size on a 5 x 7 plate, looking directly down on the ground, and shows thirty-seven exit holes, or a fraction over one to the square inch. In one of the small breeding cages, containing exactly three square feet, which had received no treatment, 132 adults emerged or 44 to the square foot. A few wings and parts of sawflies were found which may have been eaten by carabid beetles, and these would have increased the total number.

The greatest number of adults were seen on a visit to the orchard June 12th. They were especially abundant in an opening where a number of peach trees had been cut out; here they collected in swarms on the grass and weeds. They were so numerous as to make a slight rustling sound.

Needing adult specimens for our collection, etc., 462 specimens were taken, with an ordinary twelve-inch net, by sweeping it over the grass and weeds for about ten seconds. Twelve eggs were the largest number noted on a single leaf.

NATURAL ENEMIES.

Considerable time was spent looking for parasites, especially of the egg and larva, but no hymenopterous parasite or fungous disease was observed attacking either. Numerous carabid

beetles belonging to the genus *Harpalus* were present in the section where the sawflies were especially abundant. Many fragments of the adults, which had evidently been eaten, were found in the breeding cages and while these beetles were not observed feeding on the sawflies, their presence indicated that such may have been the case. Numbers of small toads in the orchards may have also helped to reduce the numbers.

LIFE HISTORY.

The spring of 1907 was cold and backward, and the dates here given are considerably later than they would be in a normal season. This is shown in one or two cases where the date for the previous season is given. The various stages probably overlapped each other much more than they would in a normal season. Mr. Barnes remarked that he thought the adults were seen for a longer period and the larvae were feeding longer than they were the year before.

The adult sawfly emerges from the ground the last of May or first of June. The first adults were observed June 4th and the last date that any were seen was June 27th. They were the most abundant on June 12th, while in 1906 the majority had disappeared by June 14th. The eggs were first found on June 12th, eight days after the first adults were observed. These were found only after considerable searching, and then but five, one leaf with two and three with one each; the majority of the eggs were laid after June 14th. The eggs hatch in six to eight days, the first larvae being observed June 20th. In 1906 many eggs had hatched by June 14th. The larvae become grown in eight to ten days, considerable injury having been done to trees not sprayed by the end of June. The larvae go into the ground and remain until the following spring. The larvae transformed rather irregularly, pupae being found from May 21st until after the middle of June. A few larvae were found June 20th, and while no further notes were made, it is quite probable that at least some of these remain in the larval stage until the following spring. Adults began to appear fourteen days after the first pupae were observed. There is but one brood in a season.

HABITS.

After emerging, the adults collect together in groups or swarm in sunny places. At the time the adults were the most

numerous (June 12th) but few were seen on the trees, but in places where trees had been cut out they were very numerous, flying around and running over the grass and weeds. While the sun was shining they were very active, but when a cloud passed over the sun they would settle down and become quiet. The next visit to the orchard was on June 14th, which was a cloudy, windy day, and the insects were very quiet, even sluggish. On the previous date many of the insects were mating but the females were not observed in the act of ovipositing. The small whitish eggs are laid horizontally on the surface of the under side of the leaf along the midrib and on the basal portion of the leaf. See Plate II, a. The larva after hatching crawls to the edge of the leaf and soon spins a web of a few whitish silken threads over itself. When it begins to feed it eats a narrow strip inward from the edge and by means of the web draws or rolls the corner of the portion on which it rests over itself, forming a case within which it stays during the day, coming out to feed towards dark. Much of the damage is done when the larvae are nearly full-grown. Leaves partly eaten and with the characteristic rolling are shown on Plate I. The midrib of the leaf is left, and to it is often attached more or less of the adjoining tissue, thus giving to the foliage on the infested trees a peculiar shredded appearance. Small trees, set to replace large trees that had been removed, were often found nearly stripped while the surrounding large trees might show but little of the work. This may be due to their preference for sunny places.

After the larvae become full-grown, they go into the ground, where they remain until the following year. Observations regarding these larvae were made in April and May. From considerable digging and many measurements the majority of the larvae were found to be about three inches deep, though some were within two inches of the surface, and the deepest were between five and six inches. The only larvae found less than two inches deep were three that were obstructed by a large flat stone. Larvae occurred within six inches of the tree trunk and halfway to the adjoining tree, or in other words, they could be found in the soil all the way from one tree to another, but were the thickest about thirty inches from the base of the tree. The larva forms a small round unlined cell about one-fourth of an inch in diameter within which it remains curled up. The

color of the larvae had changed from pale bluish green to a bright apple green. Larvae examined early in November had assumed this color.

When the larva pupates, no cell is formed, the larval skin is discarded and usually remains attached to the last abdominal segment, and the pupa is free. It has the same general shape as the adult; the antennae, legs and other appendages simply with a thin covering. Pupae are shown on Plate III, c.

EXPERIMENTS IN CHECKING THE INSECT.

At the time the experiments were started it was not definitely known that peach foliage could be sprayed in Connecticut with arsenate of lead, or in fact with any spray mixture. It was well-known that Bordeaux mixture was injurious to the foliage, and statements had been made to the effect that arsenate of lead was injurious. Three methods of combating this pest were tried, (1) cultivating the soil thoroughly while the insect was in the pupal stage; (2) treating the soil with carbon disulphide during the same period; (3) poisoning the larvae soon after they hatch by spraying the foliage with internal poisons.

Cultivating the Soil.

We have found in rearing sawflies that certain species are easily killed by disturbing the soil after they have gone into it to pupate. This suggested cultivating the soil thoroughly, especially near the trees, while the peach sawfly was in the pupal stage, as a means of reducing its numbers.

In order to note definitely the results, tight wire-covered cages were made and placed around a number of trees to retain any adults that might emerge within the area. These cages consisted of frames six feet square made of boards seven or eight inches wide and covered with wire mosquito netting. Each cage was built around a tree, the tree being in the center, with the netting fastened to the tops of the frames and fitted tightly around the tree. The cages were hinged at the middle so that one side could be raised and the soil cultivated halfway around the tree. This side could then be lowered and the opposite side raised and the soil cultivated on that side. The sides were then banked with earth to make the cage tight. A view of these

cages is shown on Plate V, a., and a nearer view of a cage with one side raised is shown on Plate V, b.

Two cages were left as checks, and in four the soil was cultivated, once, twice, three and four times respectively. The ground was stirred as thoroughly as possible with a spade to a depth of at least four inches. All lumps were crushed, making the cultivation probably more thorough than would be possible with any of the ordinary orchard tools. The dates, number of times cultivated, etc., are given in the following table:

Cage No.	1st cultivation	2d cultivation	3d cultivation	4th cultivation	Condition June 12 (No. adults)	Condition June 14
2	May 23	-----	-----	-----	About 12	Many adults
3 (check)	-----	-----	-----	-----	About 12	Rather more than in cultivated cages
7	-----	May 28	June 4	-----	6-8	Many adults
4	-----	May 28	June 4	June 7	3	Many adults
5	May 24	May 28	June 4	June 7	12 or more	Many adults
8 (check)	-----	-----	-----	-----	About 50 adults*	Rather more than in cultivated cages

The cultivation seemed to slightly delay the development of the insect and on June 14th adults had emerged in the check or untreated cages than in the cultivated; but at the next visit there was very little difference. Slight difference was noted between the cages cultivated a different number of times, and even in the cage where the soil was cultivated four times, which would not be practicable in orchard work, the treatment did little more than to retard the development of the insects.

During the latter part of May the orchard was plowed with a light gang plow, turning three furrows from two and one-half to three inches deep; this turned up many larvae, but there were still many left below the bottom of the furrow, and the majority of those that were plowed up emerged, as was shown by the numerous exit holes.

Carbon Disulphide.

Carbon disulphide has long been used in France against the grape phylloxera. The substance is injected into the soil around the vines, and the liquid evaporates, though much more slowly

* No. 8 was on rather higher ground than the other check, No. 3. No. 7 was a tree in row opposite No. 8.

than it does in the air, and spreads through the soil. It is used in this country in various ways for underground insects, especially in killing ants. Professor Slingerland of Cornell University has used it successfully in experiments against the cabbage maggot.*

In our tests two cages were used like those described for the cultivation experiments. These cages were placed in the rows with the others, and the same check cages served for both experiments.

In one cage the carbon disulphide was used at the rate of one fluid ounce to a square yard, and in the other twice that amount, two ounces to a square yard. Holes five or six inches deep were made about eighteen inches apart, or four to the square yard, and an ounce of the liquid was divided between the four holes, or about two teaspoonfuls put in each hole, after which the opening was quickly closed with the foot.

The ground in the second cage was treated in the same manner excepting that double the quantity was used. This treatment proved effective, as no adults emerged in either cage. The insects might have been killed with a smaller amount of carbon disulphide, although the actual amount required would depend upon the mechanical condition of the soil. A light, dry, porous soil will require more than a heavy, compact, moist soil, as in the former the carbon disulphide is evaporated much more rapidly and the fumes would not be retained long enough to kill the insects unless a large quantity was used. The greatest drawback, however, is that there is no tool on the market with which the carbon disulphide can be injected into the soil. An instrument was devised by Mr. McGowen, inventor of the McGowen spray nozzle, called the McGowen Injector, and was suited for just such work as is mentioned above. The injector was put on the market, but owing to the small demand for such an instrument, its manufacture was discontinued.

Treating an orchard with carbon disulphide, even with a suitable injector, would of course be very expensive, but the experiment was made before we were sure that spraying could be practiced, and had the latter proved impracticable, this would have been the only treatment we could recommend.

* Cornell Expt. Station Bull. 78, p. 531, 1894.

In the above cultivation experiments and in those with carbon disulphide duplicate tests were made with small cages containing three square feet. These tests gave similar results to those of the large cages.

Spraying with Poisons.

At the beginning of the season we were in doubt as to whether the peach foliage could be sprayed with any poison. Dr. J. B. Smith, State Entomologist of New Jersey, informed us that he had used arsenate of lead on peach foliage without apparent injury. A statement was made by Prof. A. L. Quaintance of the Bureau of Entomology that in some experiments with arsenical poisons on peach foliage, all materials used injured either the foliage or the fruit.* As soon as the leaves were out sufficiently to make a test, fourteen small peach trees on the station grounds were thoroughly sprayed with arsenate of lead at the rate of one ounce in one gallon of water, which is about equal to three pounds in fifty gallons. No injury followed. This test was repeated with another brand of arsenate of lead with the same results.

The following materials were applied in Barnes Brothers' orchard to note the effect on the trees and insects:

Vreeland's arsenate of lead	3 lbs. in 50 gal. water	5 trees
" " " "	1½ lbs. in 50 gal. water	5 trees
Paris green	½ lb., 3 lbs. lime in 50 gal. water	10 trees
Hellebore,	3 lbs. in 50 gal. water	6 trees

These trees were sprayed on the forenoon of July 6th, and the application was followed by a light shower that evening. A visit was made to the orchard July 9th, and it was found that through a mistake these trees had all been resprayed that morning with arsenate of lead, which was being used on the remainder of the orchard. These trees were examined several times, and no injury was noted even where the Paris green was applied.

Extensive Spraying Operation by the Owners.

Probably the most extensive spraying operation ever undertaken in the Eastern States in a peach orchard when in foliage was carried out by the Barnes Brothers during this last season. Several hundred pounds of arsenate of lead was applied to

* Bureau of Entomology Bull. No. 67, p. 47, 1907.

4,000-5,000 trees between June 24th and July 10th. The owners intended to spray more, but during the first week in July had to suspend operations to wait for a shipment of lead arsenate. The arsenate of lead purchased was manufactured by the Powers-Weightman-Rosengarten Company of Philadelphia,* and was applied at the rate of $2\frac{1}{2}$ to 3 lbs. in fifty gallons of water.

The larvae, like many sawfly larvae, were very readily killed by the poison, and probably used at one-half this strength (one and one-half pounds in fifty gallons) would have been effective. Mr. Barnes was unable to be in the orchards much of the time to see that the men thoroughly covered the foliage, and the stronger solution was used partly for this reason. Plate VI, a., shows the sprayers at work in this orchard.

Owing to the peculiar season, the young larvae probably appeared more irregularly than they would in an average season. During the first ten days of July many trees showed considerable of the insect work, and many of the larvae became full-grown, but there were still many partly grown larvae present on the same trees which might add much to the damage already done, and the spraying was continued until the 9th of July. The treatment was entirely successful, the work of the insect being checked wherever the trees were sprayed. From my notes of July 3d regarding trees sprayed about the 24th of June:—"Found many dead larvae in the rolled leaves on the sprayed trees, and the foliage shows a marked difference from that on trees not sprayed."

The writer examined many of the sprayed trees for two or three weeks following the operation, and in no case was any injury to the foliage seen. Mr. Barnes watched throughout the season, a number of trees which had received an extra heavy coating of arsenate of lead, and though the mixture showed on the foliage until the leaves fell, no injury was observed.

DESCRIPTION.

Egg. The eggs are pearly white in color, 1.64 mm. (average of six) in length, and .6 mm. (average of four) wide, sides nearly straight and of uniform width, the ends regularly and broadly rounded. Occasionally an egg is very slightly curved.

* Analysis, Conn. Agric. Exper. Stat. Bull. 157, p. 5, 1907. (See page 323 of this report.)

They are laid longitudinally along the midrib of the leaf. See Plate II, a.

Larva. When first hatched is pearly white in color with brown eye-spots on either side of the head. Mouth parts and antennae tipped with brown. Antennae .16 mm. long. Length about 2.5 mm. Head about .5 mm. wide, exceeding the body, which is .45 mm. wide back of head. Body fairly uniform in width, tapering somewhat towards anal end. Abdominal segments slightly wrinkled. Anal segments with a pair of three jointed appendages about .12 mm. long, the basal joint large, the second smaller and shorter, the third tapering to a point.

Full-Grown Larva. Length 15 mm., width 2.25 mm. Color pale bluish green, including the head; mouth parts, antennae, and anal appendages brownish. First thoracic segment with a dorsal transverse mark between two sublateral spots. Head roundish, about 1.5 mm. wide. Antennae slender, seven-jointed. Abdomen without prolegs, the segments wrinkled transversely, four wrinkles to a segment; the last abdominal segment flattened, tipped with a row of slender hairs and with a pair of three jointed appendages situated laterally on the ventral side. The larvae are shown on Plate II, b. and c.

After entering the ground the color of the larva changes to a bright apple green.

Pupa. No cell or pupa case is formed. The pupa is naked with all the appendages free, simply covered with a thin membrane. The head and thorax apple green, abdomen and appendages yellowish green. Before emerging the color and markings of the adult insect are plainly visible. Shown on Plate III, c.

Adult.

Dr. MacGillivray has described the female as follows:

"*Female*—Body black, with the following parts yellow: the labrum and clypeus broadly, the posterior orbits, the front orbits with a band extending to the occiput, with two tooth-like projections on the mesal side near the eye, a pair of lunate marks behind the ocelli, a small spot on the hypoclypeal area, the palpi, the V-spot, the tegulae and base of the wings, the scutellum, the post-scutellum, a small irregular spot on the pleura, and the legs, except the extreme bases of the coxae, becoming rufous

beyond the middle of the tibiae; mandibles and abdomen rufous; antennae with thirty segments, the third and fourth subequal in length. Length, 10 mm."*

Male. Color and markings similar to female except the following:—The front orbits with a large irregular yellow spot opposite the eye, the lower edge continuous with the yellow of the posterior orbits. The yellow band extending from the inner superior border of the eye to the occiput. Antennal pits and the under side of the first basal antennal joints yellow. The lunate marks behind the ocellus smaller. Abdomen with the sides blackish and at least the posterior dorsal margins of the segments blackish, in a few specimens almost the entire dorsal surface of abdomen blackish. The ventral side rufous except at the lateral edges. Anal appendages rufous. Average length 9 mm.

Both sexes and their characteristic facial marking are shown on Plate III, a. and b.

DISTRIBUTION.

Our attention was called to this insect in 1906, and Barnes Brothers observed its work in 1905. Since then we have received no complaint from other orchardists of injury that could specifically be laid to this pest. Observations regarding the distribution of the peach sawfly have been made as follows, the larger orchards having been visited especially to look for the insect or its work:

PLACES WHERE THE INSECT HAS BEEN FOUND.

New Haven, June, in three city gardens and in garden of Experiment Station.

Meriden, July 9th, small peach orchard of E. M. Ives; occasional leaves had been eaten, and a few full-grown larvae were found.

Centerville, July 12th, orchard of George C. Neal. A number of larvae. The pest evidently well established.

North Haven, July 12th. The insect was present upon a few peach trees in a henyard.

East Wallingford, July 17th, orchard of George A. Hopson.

* Canadian Entomologist, Vol. XXXIX, p. 308, 1907.

Found considerable work of the insect, a few small trees with leaves nearly all stripped.

Orchard of Linus Hall, the insect rather more prevalent than in the orchard above mentioned.

Middlefield, July 17th, orchard of Charles E. Lyman. Conditions about the same as in East Wallingford.

Farmington, August 7th, orchard of Root Brothers. A few leaves eaten by this insect on two or three trees.

Young orchard of Prof. H. W. Hillyer showed evidences of the insect.

Mr. J. Norris Barnes reported the insect in their orchards at Cheshire and also at Durham.

ORCHARDS EXAMINED WITH NO INDICATION OF THE SAWFLY.

West Haven, July 5th, orchard of N. S. Platt.

Westport, July 16th, orchard of S. B. Wakeman.

Seymour, August 13th, orchards of Hale & Coleman.

Rocky Hill, August 15th, orchards of W. F. Griswold.

South Glastonbury, August 15, orchard of J. H. Hale.

Hartford, September 12th, peach trees in four city gardens.

New Canaan, Sept. 18th, orchard near Stephen Hoyt's Sons' Nursery.

Norwalk, October 3d, small orchard of Comstock & Lyon.

As far as we know, this insect has not been observed outside of Connecticut. A note was published in Bulletin 67 of the Bureau of Entomology, p. 87, stating that it had been observed in New Jersey and also in Pennsylvania, but these records refer to the distribution of an entirely different sawfly, *Priophorus acericaulis* MacGillivray, which confines its work to maple trees.

WILL THE PEACH SAWFLY BECOME A SERIOUS PEST?

Since the peach sawfly has been brought to the attention of the fruit growers, there have been many questions regarding its importance as a pest. It is hard for the orchardists to become reconciled to the fact that they have got to spray their orchards every one or two years for the San José scale, and the possibility of having to give their orchards an additional spraying for this pest is indeed discouraging.

It is impossible to predict with any certainty regarding this new pest. The sawfly promises to become distributed throughout the state, as it has been found in New Haven and Middlesex counties at points nearly thirty miles apart; but whether it will become numerous enough to cause serious injury depends largely upon the rapidity with which it multiplies, and the part that natural enemies may take in reducing its number. From our observations, the numbers are not greatly increased during a single season, and it would seem that the pest would necessarily have to be present in an orchard several seasons before it would do extensive damage. The larvae are very easily killed by arsenical poisons, and it is quite possible that one application may reduce their numbers sufficiently so that the operation would not have to be repeated for two or three years. It will be necessary to study the insect for a number of seasons before we can judge regarding the seriousness of the new pest that has been found in our state.

ACKNOWLEDGMENTS.

The writer is indebted to Dr. Britton, under whose direction the work has been done, for much help and many suggestions.

To Barnes Brothers, who placed their orchard at our disposal, furnished lumber for breeding cages, and assisted the work in many ways.

To Mr. George A. Hopson and Mr. Charles E. Lyman, who spent considerable time at a very busy season, conducting the writer through their orchards.

RECOMMENDATIONS.

From our experience we recommend spraying the foliage with arsenate of lead, using it at the rate of one and one-half to three pounds in forty to fifty gallons of water. This should be applied as soon as the larvae begin to hatch, or if a large area is to be sprayed with a limited amount of help, the work could probably be started shortly after the eggs are laid. The exact date will depend, of course, upon the season; this was found to vary about two weeks during the past two seasons. The point is, the larval stage is short and the work must be done quickly at the proper time, and in order to determine this a close watch must be kept of the progress of the development of the insect.

Carbon bisulphide will kill the insect in the larval and pupal stages, but is probably too expensive to warrant its use; besides there is no injector with which to apply it, on the market at the present time.

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PROGRESS OF THE WORK OF CONTROLLING THE GYPSY MOTH IN CONNECTICUT.

The first account of the discovery of the gypsy moth in Connecticut in March, 1906, was published in Bulletin 153 of this station. The report for 1905 was then being prepared, and in it was included, on page 246, a more complete history of the discovery. Work was started immediately and kept up until September 1st. The details were published in full in the report for 1906, page 235. The present paper is a report of progress during the calendar year of 1907.

Beginning November 16th, 1906, Mr. George H. Hollister has had immediate supervision of the work, and to his faithfulness and ability much of its success is due. During the winter three men worked with Mr. Hollister, scouting for egg-masses, pruning trees and cutting brush. After the caterpillar season began, the force was increased, twenty being the greatest number of men employed at any one time during the banding season. Excellent progress has been made in the suppression work, as a large number of trees were banded, brush cut and trees pruned over a large area, and the total number of caterpillars found was less than one-third the number taken during 1906.

On September 1st the work was suspended on account of the annual inspection of nurseries, and again resumed on November

18th. Details of the suppression work are given in the following pages.

SCOUTING AND DESTROYING EGG-MASSSES.

All trees throughout the infested region, including those in the village and as far north as the cemetery road, were examined by the men during the winter. In the immediate vicinity of known infestations, fences, walls and buildings were also carefully inspected. Plate VII shows men engaged in scouting and destroying egg-masses. Creosote is applied by means of a brush, enough being used to thoroughly soak the egg-mass, and this prevents the eggs from hatching. Much of this territory was again examined in December. About 106 unhatched egg-masses laid in 1906 were found and destroyed by the men employed by the state. Considerable time in summer was spent scouting for caterpillars.

GOVERNMENT COÖPERATION IN SCOUTING.

Following previous arrangement by correspondence, Mr. D. M. Rogers, special field agent in charge of the Government work against the gypsy and brown-tail moths, put four men at work scouting about Stonington on March 20th, and later their force was increased to five. These men were instructed to make a careful search over the whole town of Stonington and the easterly portion of Groton near West Mystic, eastward surrounding Westerly, R. I., and north to include a portion of the town of North Stonington. The Government men examined not only the infested region, which was later scouted by state men, but a large area surrounding this region. No egg-masses were found outside the limits previously known to be infested. Twelve egg-masses were found by the Government scouts, who were engaged about four weeks in examining this territory.

DESTROYING EGG-MASSSES IN STONE WALLS.

In several of the worst infested spots caterpillars transformed in stone walls, and the females there laid their eggs. In order to destroy them it was necessary to overhaul the stones and treat each egg-mass with creosote. Around the places of M. Chesebro, F. Allen, and near the Alexander Rose estate on North Main street sections of stone wall were overhauled and relaid, altogether about fifteen rods being thus treated.

EXAMINING WOODPILES.

Piles of wood, lumber and rubbish near which caterpillars were found were suspected of containing egg-masses and were therefore overhauled and examined. One pile of old railroad ties at F. Allen's (shown on Plate X, a.) contained seven egg-masses. The pile of waste lumber, packing boxes, etc., at the velvet mill was also looked over, and six egg-masses found. Ten such piles of rubbish, lumber and fuel were examined.

PRUNING AND SCRAPING ORCHARD TREES.

There are many old apple trees in and about the infested region at Stonington. Some of these are in orchards and were planted, but others, probably chance seedlings, are scattered over the fields or are growing beside the stone walls. A large proportion of them have been neglected for many years, and the tops were filled with a tangle of living and dead branches, and the trunks and larger limbs covered with lichens and loose rough bark. As the gypsy caterpillars are found on such trees, it was absolutely necessary to put the trees in such shape that effective work could be done in controlling the insect. During January a heavy fall of snow made brush cutting impracticable, and the men went to work pruning and scraping these old apple trees. The dead wood was first removed, then enough thinning was done in the tops to let in the light and air. In all about 450 such trees were pruned during the year, and over two hundred trees were scraped. The wounds were painted wherever large branches were cut. Views of the pruning operations are shown on Plate VIII.

Rough bark on the trunk and branches of a tree enables the caterpillars to find protection under the upturned edges of bark so that they will not crawl under the burlap bands. Likewise, if the top of a tree is thick and dark, the caterpillars there are sufficiently protected, and cannot be trapped under the bands.

FILLING AND TINNING CAVITIES.

Many of the trees described above contained cavities caused by the neglect of broken and decayed branches, and these cavities were convenient places for the caterpillars to hide out of reach of all enemies. In them caterpillars will transform,

and later perhaps egg-masses will be laid therein and escape discovery. It was therefore necessary to fill these cavities so as to exclude the caterpillars. In some cases this can best be done by filling the opening with stones and cement, and in others it is better to nail a piece of tin over the opening, fitting it around the edges so that caterpillars cannot crawl under it. Wherever tin was used, the metal was painted over with dark paint to make it as inconspicuous as possible. In this manner cavities were filled and covered in 130 trees during the year.

Plate XII shows a tree that has been scraped and pruned and the cavities filled.

BANDING TREES WITH BURLAP.

Burlap bands were placed around the trunks or stems of trees as described in the report for last year, page 238, but the bands were applied to trees over a much larger area than was covered last year, nearly ten times as many bands being used. All trees were banded through the streets and back yards of the village and as far north as the cemetery road from the Wequetequock River west to Sheridan's Corner, on the Mystic road. All trees for a distance of about two hundred yards north of the cemetery road, including three apple orchards, were also banded, but no caterpillars were found there.

During July caterpillars were found on maple trees along the drive leading from the Mystic road to Walnut Grove. All trees in this vicinity were banded at once, about eight hundred being so treated.

Altogether about thirteen thousand trees were banded in 1907. The appearance of banded trees is shown on Plate XI and the method of applying the bands may be seen on Plate X, b. The first banding was done about May 25th. Burlap (eight ounce weight) was purchased from Boston, all cut into ten inch strips ready for use. In the infested area these bands were examined each day through the caterpillar season; outside this area they were turned every second day, and later twice a week.

DESTROYING THE CATERPILLARS.

The territory was divided into sections, and each man engaged in examining bands was given a section of banded trees. Notes were kept each day of all caterpillars found and of the locality

where taken. Thus at the end of the season we had a record of the entire matter, and knew where to look for the greatest number of egg-masses. The caterpillars were gathered with forceps and destroyed in the same manner as last year, by dropping them into small bottles of alcohol carried by the men.

CUTTING BRUSH.

Plans were made to clear from brush all of the land between the northernmost extension of the water from Stonington harbor to the Wequetequock River and as far north as the cemetery road. Mr. Phelps, at his own expense, had cut considerable brush just east of his residence and south of the cemetery road, and by January 8th, 1907, a strip had been cleared from water to water, though not very wide, near the east entrance to the cemetery. During the first part of the winter there was little snow, and the brush cutting work could be carried along without hindrance. Some brush cut during August had not been burned, and this was gathered and fired. Considerable heavy brush east of the cemetery was cut in early summer, and the section between North Main street and Elm street south of the cemetery road was entirely cleared of brush except a small patch just east of Mr. Phelps' house, which was cut in November, 1907. The heavy brush near Mr. Atwood's was also cut and the remaining trees pruned, but it was not possible with the force employed to cut all of the scattering brush in the pasture north of Mr. Atwood's house. This area was finished up in December, 1907. As a few caterpillars were found at Walnut Grove in July, a gang of men were set at work cutting brush in this vicinity. Mr. Hollister estimates that during the past year a hundred acres of brush land has been cut over, and some of this was heavily covered with green brier (*Smilax rotundifolia*), often called "bull brier," making the work extremely difficult. Some of the men were so badly poisoned with poison ivy that for a few days they were unable to work. Brush along the boundary walls of fields and meadows has also been cleaned up over an area of about three-fourths of a square mile. Brush cutting work is shown on Plate IX.

INFESTATION AT WALNUT GROVE.

About the middle of July the men found some gypsy caterpillars on the trees beside the drive leading from the Mystic road

to Walnut Grove. Men were at once put at work there, and a considerable area of brush cleaned up. Some eight hundred more trees were banded in the vicinity and though much hunting was done for caterpillars, only a few were found, and most of these were on trees between the house and the northernmost extremity of water. Though the trees have since been examined very carefully for egg-masses, none have been found. Not even an old one has been discovered. How the caterpillars reached this place is a matter of conjecture, but it is possible that an egg-mass or a portion of an egg-mass was blown across the water on the ice. On the other hand, it is possible that one or more egg-masses were laid at Walnut Grove in 1906 and escaped detection.

INFESTATION OF SPRUCE TREES AT THE STANTON PLACE.

During August, after the caterpillars had transformed, Mr. Hollister, on looking into the top of one of the Norway spruces of which there are several on the Stanton place, noticed some female gypsy moths laying eggs. This tree was immediately given a thorough examination, and over fifty new egg-masses were found. These were creosoted, and later the tree was cut and burned. A similar number of egg-masses was found in the other spruce trees in December. Although these trees were all banded, few caterpillars were taken from under the bands, and there was no indication that the trees were infested to any such extent. The tops of the trees were thick and dark, and furnished to the caterpillars all the protection necessary, hence they did not descend to hide under the bands. The caterpillars had eaten some of the leaves in the tops of the trees, but not enough to be noticeable from the ground. The excrement even did not indicate their presence by dropping to the ground, but was caught and held by the thick leafy branches underneath. It was an extremely difficult matter to find and destroy the egg-masses on these trees, as some of them were at the extremities of the branches on the small twigs, and nearly all on the under side. In spite of the very thorough examination given these trees, some egg-masses may have been overlooked, and a close watch must be kept on them next season. No egg-masses were found on the arbor-vitae trees growing near by on the premises.

STATISTICS.

	1906	1907
Egg-masses laid during preceding year, number destroyed	29	118*
Egg-masses laid during same year, number destroyed	47	70
Caterpillars, number destroyed	10,000	2,936
Pupae, number destroyed	47	200
Trees banded with burlap, number of	1,300	13,000
Funds expended by the state†	\$1,500.00	\$4,550.00
" " " " government	—	272.00

TRANSFORMATIONS OF GYPSY MOTH IN CONNECTICUT IN 1907.

The spring was an unusually late one, all forms of vegetation being fully two weeks later than usual. Ordinarily the eggs hatch soon after May 1st, but a cluster placed in the breeding cage did not hatch until May 18th, when 382 caterpillars had emerged from it, and the first caterpillar taken from the trees was found on June 8th. The first pupa of the season was found on July 25th, and only a few had been taken August 1st. The pupa stage lasts from ten to fourteen days, when the adults emerge. They soon mate and the females lay eggs, which hatch the following May. Thus about nine months or three-fourths of the year are passed by this insect in the egg stage. Caterpillars, adults and egg-masses are shown on Plate XIII.

MEN EMPLOYED IN THE WORK.

Throughout the year Mr. G. H. Hollister has acted as local superintendent and has been given full authority to employ or discharge men as he saw fit. All other men employed have been residents of Stonington or vicinity. Laborers were paid \$1.50 per day of nine hours for the time which they worked, but during the summer, when most needed, they were given \$9.00 per week as a guarantee against loss of wages on account of bad weather, and reported each morning, even though stormy, as some of the men could be used in sharpening and repairing tools. Through the winter months Mr. Hollister and three men worked scouting, cutting brush, pruning and scraping trees, but the force was increased as needed, until during the caterpillar season twenty men were employed.

* Including twelve found and destroyed by government scouts.

† These amounts are for the calendar and not for the fiscal year.

All work was suspended September 1st, and Mr. Hollister assisted in inspecting the nurseries of the state. On November 18th work was resumed at Stonington by Mr. Hollister and six men.

FUNDS.

The report for 1906 explained (page 245) how a portion of the general fund received by the station from the state was used in controlling the gypsy moth and also how eight hundred dollars was appropriated for the purpose by the State Board of Agriculture. During 1907 the expenses were met from the insect pest fund prior to the passage of a bill by the legislature providing for the prosecution of the control work. As this bill did not finally become a law until June 5th, and as none of the money could be used to pay bills contracted before that date, we came very near being obliged to stop work at a critical time for lack of funds. In order to keep the men at work the State Board of Agriculture appropriated one hundred dollars on May 25th. The new state appropriation of one thousand dollars became available on June 5th, and was immediately drawn, and as soon as the legislature adjourned the State Board of Control appropriated fifteen hundred dollars more, which amount was nearly all expended when the work was temporarily stopped on September 1st.

After the leaves had fallen so that scouting for egg-masses could be done advantageously, the Board of Control granted another one thousand dollars, which had been only about half expended on January 1st, 1908. Thus during the calendar year approximately \$4,550 had been used, and this, together with the amount expended in 1906, make a total of more than six thousand dollars thus far expended in attempting to exterminate the gypsy moth colony at Stonington.

LEGISLATION.

Prior to June 5th, 1907, no special legislation regarding the gypsy or brown-tail moths had been enacted in Connecticut, and in the control work at Stonington the state entomologist had no authority except that granted under the insect pest law—Sections 4386-4390 of the Revised Statutes. Consequently it was necessary to obtain the owners' permission before cutting brush,

pruning trees, etc., though clearly we had the right to enter any premises in the performance of our duties. More authority, as well as funds, was needed, and in consultation with a committee of the Board of Agriculture on January 30th a rough draft of a bill was prepared. By request of Colonel James F. Brown, Secretary of the Board, this bill was introduced by Representative Allyn of Ledyard. Later we had this measure examined by legal counsel, and while not sacrificing any of the essentials, the bill was put in better legal form and introduced as a substitute at a hearing before the agricultural committee on February 19th. This committee, after changing certain portions of the bill, reported favorably upon the substitute, but though we urged early action and explained the necessity of it, the appropriations committee refused to consider the measure before March 26th, when the bill was up for a hearing. There was no opposition to the measure except within the committee, which, after making more changes, finally reported favorably. This bill passed the House May 14th, and the following day the state entomologist went to Hartford, examined the bill, and consulting with other state officials learned that the money would not be available until July 1st, and would not be paid over by the state treasurer until the end of the quarter, or October 1st. The bill was therefore recalled, amended, and again passed the House May 15th. In due time the Senate acted favorably upon it and the Governor signed it on June 5th, making it a part of the law of the state.

The text of the new law is as follows:

THE NEW LAW REGARDING THE GYPSY AND BROWN-TAIL
MOTHS.

An Act Concerning Gypsy and Brown-Tail Moths.

GENERAL ASSEMBLY,

JANUARY SESSION, A. D. 1907.

Be it enacted by the Senate and House of Representatives in General Assembly convened:

SECTION I. (Public Nuisance.) The insects commonly known as the gypsy moth and the brown-tail moth, being serious pests of vegetation, are, in all stages of their development, hereby declared to be a public nuisance.

SECTION 2. (**Authority.**) The state entomologist shall have authority to suppress and exterminate said gypsy and brown-tail moths, and may employ such assistants and laborers as he deems expedient; may cut and burn brush and worthless trees in fields, pastures, or woodlands, or along the roadsides on any public or private grounds; and may prune, spray, scrape, or fill cavities in any fruit, shade, or forest trees, or clean up any rubbish for the purpose of furthering said work. The said state entomologist, or any of his assistants, deputies, agents, or employes, shall have the right, at all times, to enter any public or private grounds in the performance of their duties.

SECTION 3. (**Living specimens must not be transported. Penalty.**) Any person transporting living eggs, larvae, pupae, or adults of the gypsy or brown-tail moths into the state, or from an infested region within the state to a region not hitherto infested, shall be fined not more than one thousand dollars or imprisoned not more than one year.

SECTION 4. (**Wilful obstruction illegal. Penalty.**) Any person wilfully obstructing or hindering said state entomologist or his assistants or employes, in the work of suppressing said insects, shall be fined not less than twenty-five nor more than five hundred dollars.

SECTION 5. (**Appropriation.**) The sum of one thousand dollars is hereby appropriated to be paid out of any money in the treasury not otherwise appropriated, for the purpose of this act for the two fiscal years ending September 30, 1909; and the board of control is hereby authorized, if said board deem it advisable, to increase said appropriation to such amount not exceeding in the aggregate the sum of ten thousand dollars as, in the opinion of said board of control and the state entomologist, is necessary, said sum to be in addition to the total amount to which said board of control is limited by law.

SECTION 6. This act shall take effect from its passage, and the appropriation provided for in section five shall become immediately available for the purpose of this act.

Approved June 5, 1907.

PROVISIONS OF THE LAW.

An examination of the preceding measure will show that the State of Connecticut has by statute provided for the control

of the gypsy and brown-tail moths. First it declares these insects to be a public nuisance. The state entomologist is thereby given authority to employ the necessary help; to enter any public or private grounds; to cut and burn brush and worthless trees; to prune, scrape, spray or fill cavities in trees, or clean up rubbish. Anyone wilfully hindering the suppression work is subject to prosecution and a heavy fine.

Anyone bringing these insects alive into the state, or from an infested region within the state to a locality not hitherto infested, is liable to be heavily fined and imprisoned, and it makes no difference whether the insects are in the egg, caterpillars, cocoon or adult stages.

This law further provides an appropriation for carrying on the work, and that the act take effect immediately upon its passage.

The text of the law with explanations was immediately printed as Bulletin of Immediate Information No. 5, and a copy distributed at every house within the infested region, and was also published in the local newspapers.

LEGISLATION AND APPROPRIATIONS FOR GYPSY MOTH WORK IN OTHER STATES.

Connecticut was not alone in enacting new laws for the suppression of the gypsy and brown-tail moths. In Maine and New Hampshire, where such legislation did not previously exist, new laws were passed in the winter or spring of 1907, giving authority and appropriations for carrying on the work. In Rhode Island, where a small appropriation had been made and expended the preceding year, the law was renewed and strengthened and a much larger appropriation granted. In Massachusetts, the state most seriously infested, the appropriation was renewed. In addition to these state appropriations Congress appropriated a large sum of money to be used by the Bureau of Entomology of the United States Department of Agriculture in coöperation with the authorities of the five infested states. The following figures give the approximate area infested by the gypsy moth and the amount appropriated for suppressing both gypsy and brown-tail moths in each state:

State.	Area Infested.	Appropriation.
Connecticut	1 square mile	\$ 10,000 (biennial)
Maine	228 " miles	30,000 (annual)
Massachusetts	3,000 " "	300,000 (biennial)
Rhode Island	25 " "	10,000 (annual)
New Hampshire	1,500 " "	25,000 (biennial)
United States		150,000 (annual)
Total	4,754 " "	\$525,000

In addition to the amounts given in the preceding table, the laws of Maine, Massachusetts and New Hampshire, require that individual owners, town and municipal authorities, take measures, when necessary, to suppress these pests on their own property, or that under their charge, the expenditures not to exceed a certain low percentage of the assessed valuation of the property. On proof that this has been properly done by cities and towns, the commonwealth may reimburse the cities and towns for a certain proportion of such sums expended in accordance with the law. In this respect, the laws of Maine and New Hampshire are based on the Massachusetts law, but in Rhode Island and Connecticut the suppression work is done entirely by state and government authorities, city, town, and private owners not being obliged to act, because extermination and not mere suppression is the end in view. Should these states ever become generally infested, a measure similar to that in Massachusetts would be necessary to control the pest, and would doubtless be enacted. In addition to the \$300,000 appropriated by the Massachusetts Legislature, the sum of \$25,000 was made available for experimental work on parasites of gypsy and brown-tail moths. Thus according to Superintendent Kirkland the money expended by the state, by towns and individual owners in the work of suppressing the gypsy and brown-tail moths in Massachusetts in 1907, amounted to a total of nearly three-quarters of a million dollars.

INTRODUCTION OF PARASITES.

Many species of parasites of gypsy and brown-tail moths have been introduced into Massachusetts by Dr. L. O. Howard in coöperation with Mr. Kirkland. Dr. Howard has made three annual trips to Europe and enlisted the aid of European ento-

mologists in the work of collecting parasitized material and sending it to this country. Parasites have been reared from this material at Mr. Kirkland's laboratory, and all hyperparasites destroyed before liberating them. The prospects for relief from this source are most promising, but it will be several years, perhaps, before the value of these parasites can be determined as a control measure. In the meantime, the other work should be continued, until it has been shown that the natural enemies alone are able to reduce the number of gypsy and brown-tail moths so materially that little or no damage will be done to property by them.

PRESENT CONDITIONS AND NECESSARY WORK FOR THE FUTURE.

The preceding pages give an account of the work which has been done in Stonington during the past year. What then are the conditions as they exist at present, and what is the outlook for the future?

About twice as great an area as is now infested or nearly two square miles has been cleared of brush, except that in some cases the season's growth has not been cut. Most of the neglected apple and other fruit trees have been pruned, scraped, and the cavities filled. The pest is well under control, though not yet exterminated. The conditions for exterminating the gypsy moth in Stonington are therefore much better than at any time since the infestation was discovered. But the work must not stop here. Trees must be banded for at least two years more, extreme thoroughness must be practiced in scouting for egg-masses and destroying them and in hunting for caterpillars both inside and outside of the present area known to be infested.

If funds are available, we shall prosecute the work along the most promising lines until the pest has been exterminated from within the borders of the State of Connecticut.

It should be borne in mind, however, that this work being done by the state is experimental, and is for the purpose of exterminating a dreadful pest from a small area. If the gypsy moth ever becomes widely distributed in Connecticut it will of course be necessary to enact laws compelling property owners to clean up their own land as is the case in Massachusetts.

THE BROWN-TAIL MOTH.

Euproctis chrysorrhæa Linn.

In the report of this station for 1902 (second report of state entomologist), page 165, is given a brief account of the brown-tail moth. The insect is also treated in Bulletin 153, issued in March, 1906. Though the brown-tail moth has not yet been found within the state, we may reasonably expect that it will appear in a few years at the most. It has been a companion pest of the gypsy moth in Massachusetts, New Hampshire and Maine, and in all of the states where suppression laws have been enacted for the latter pest the brown-tail moth has been included. The latter spreads much more rapidly, however, because the female can fly, and it has a different life history. Different combative measures are therefore necessary. We can exterminate the gypsy moth from small isolated areas, but not so with the brown-tail, though we can hold it in check, and nature supplies more effective controlling agents in the way of insect and fungous parasites than in the case of the gypsy moth. During the spring and summer of 1906 thousands of caterpillars in Massachusetts were killed in their nests by a fungous disease, thus materially checking the pest. This fungus, according to Kirkland,* was examined by Dr. G. E. Stone, botanist of the Agricultural College at Amherst, and pronounced *Empusa ulicæ* Reichardt, a species common in Europe and often serving there as an important check to the outbreaks of the brown-tail moth.

DISTRIBUTION OF THE BROWN-TAIL MOTH IN AMERICA.

First noticed in Somerville, Mass., about fifteen years ago, this insect was supposed to be some native species, but as it increased in abundance it was brought to the attention of entomologists in 1897 and pronounced the brown-tail moth, a European pest which had doubtless been introduced into this country by accident. A special appropriation was granted the Gypsy Moth Commission for fighting this insect, but all work of the commission was discontinued in 1900 because the legislature refused to grant further appropriations. Since then the brown-tail moth

*Second Annual Report of the Superintendent for Suppressing the Gypsy and Brown-Tail Moths in Mass., p. 127. 1907.

has spread rapidly toward the north and east. In Massachusetts the entire eastern portion is infested nearly as far west as the Connecticut River valley. The insect is reported from Pawtucket, East Providence and Woonsocket, R. I., though it is not known what portion of the state is infested. The moth has been found in the entire southeastern portion of New Hampshire, even as far north as the White Mountains, and it has spread through the State of Maine into the Province of New Brunswick. So far it is not known to us that it has been found in Connecticut.

HABITS AND LIFE HISTORY.

The eggs are laid on the under side of the leaves during the latter half of July, in masses smaller and more elongated than



FIG. 1.—Female brown-tail moth.
(After Fernald.)



FIG. 2.—Caterpillar of brown-tail moth.
(After Fernald.)

those of the gypsy moth. They are also more reddish in color, but are covered with hairs in much the same manner, and contain about three hundred eggs each. See Plate XIV, a.

The eggs hatch early in August, and the young caterpillars feed gregariously upon the upper leaf surface, but soon begin to fasten a number of leaves together with silken threads which

they spin, forming a nest or web on the ends of the small branches. On the approach of cold weather, about 250 caterpillars enter each web, and remain there, about one-fourth grown, through the winter, coming out early in April and feeding upon the buds, and later the opening blossoms and leaves. The caterpillars (see Figure 2) become full-grown the last of June, and are between one and two inches long, dark brown in color with an interrupted white stripe on each side of the dorsum and two conspicuous red dots or tubercles on the posterior end of the body. Long hairs arise from tubercles along the sides of the body.

The cocoons are formed often in a bunch of leaves at the ends of the twigs. Two weeks is the length of the pupal or



FIG. 3.—Web or winter nest of brown-tail moth.

(After Fernald.)

chrysalid stage, and the moths emerge usually about the middle of July.

Both sexes are similar except that the female is larger, pure white, with brown hairs on the end of the abdomen, giving it the name of the brown-tail moth. The wing expanse of the female is about one and one-half inches. Both sexes fly at

night, and are strongly attracted by electric lights. The adults, cocoons, winter nests and egg-masses are shown on Plate XIV. See also Figures 1, 2 and 3.

FOOD PLANTS.

Fernald and Kirkland give a list* of about eighty species of trees and plants on which the caterpillars are known to feed. The pear is the first preference of the caterpillars, followed by the apple and the stone fruits. Maples, elms and oaks are perhaps the chief kinds of shade and forest trees liable to be injured. As the gypsy caterpillars feed upon over six hundred different kinds of plants, it will be seen that the brown-tail is much more limited in regard to its food plants. Pear, apple and oak trees are stripped by the brown-tail caterpillars.

IRRITATION CAUSED BY THE CATERPILLARS.

The hairs of the caterpillars are barbed and brittle, and break off easily. When they come in contact with the human skin, they cause an irritation or rash which is quite serious with certain persons. The worst forms of rash are caused by actual contact with the caterpillars, but the broken hairs which blow about will cause the milder forms. The matter has been carefully studied by Dr. E. E. Tyzzer† of the Harvard Medical School, who finds in these hairs a definite poisonous principle which causes certain changes in the blood. The long hairs do not seem to possess this quality, but the short barbed hairs of the red dorsal tubercles are the ones chiefly responsible, though similar hairs occur with the long ones on various portions of the caterpillar, and on the posterior extremity of the body of the adult. In making the cocoon the hairs are rubbed from the caterpillar and woven into the new structure, and those from the adult female are worked into the formation of the egg-mass, so that either cocoon or egg-mass may produce the rash. Such hairs are doubtless cast with the skin when the caterpillars molt, and are often rubbed or broken off from their bodies and blown

* The Brown-Tail Moth, Mass. Board of Agriculture, p. 57. 1903.

† Second Annual Report of the Superintendent for Suppressing the Gypsy and Brown-Tail Moths, p. 154. 1907.

about, and coming in contact with the skin of human beings cause the brown-tail rash.

As a remedy for this rash Kirkland recommends the following, which should be well shaken together and rubbed thoroughly upon the affected parts:

Carbolic acid	$\frac{1}{2}$ drachm
Zinc oxide	$\frac{1}{2}$ ounce
Lime water	8 ounces

METHODS OF CONTROL.

The best of all remedies against this insect is the destruction of the caterpillars in the winter webs or nests, which can be readily seen at the ends of the twigs throughout the winter. These should be clipped off with a long-handled tree pruner



FIG. 4.—Tree pruner.

such as is shown in Figure 4, gathered and burned. The caterpillars are hibernating in these nests from October to April. It is of no use to cut off the nests and leave them on the ground, as the caterpillars may remain uninjured and in spring crawl back to the trees.

Spraying with poison is much more effective against this insect than against the gypsy caterpillar. Arsenate of lead at the rate of three pounds in fifty gallons of water is recommended for the young caterpillars, but this quantity should be increased to five pounds for the large or nearly full-grown caterpillars. Paris green at the rate of one pound in one hundred gallons may

be used in place of arsenate of lead, but lime should be added to prevent injury to the foliage. Arsenate of lead causes no injury, and adheres to the foliage for a long time.

Caterpillars which are crawling about in great numbers on trees, fences, etc., should of course be destroyed. Sprinkling with kerosene, either pure or in an emulsion, or even with strong soapsuds, is of considerable value in destroying them.

Trees which are free from caterpillars may be kept so during the season by applying a sticky band to prevent the caterpillars from crawling up the trunk. Wherever the brown-tail moth becomes abundant, it must of necessity be held in check chiefly through the efforts of property owners in coöperation with town or city authorities. The problem does not require the same degree of care as is necessary in handling the gypsy moth, and therefore it is not as essential that it be done by competent men employed by the state.

MOSQUITO BREEDING CONDITIONS AT NIAN TIC AND CRESCENT BEACH IN 1907.

On August 16th a letter was received from Mr. Anson T. McCook of Niantic, calling attention to the mosquito nuisance in the vicinity of Niantic and Crescent Beach, which had been worse this season than ever before, and expressing a desire to aid in abating it. By his request an examination was therefore made of the worst areas, Mr. Walden visiting the region on August 28th, and reporting as follows:

The examination here reported was made August 28th. The writer was accompanied by Mr. A. T. McCook, and the places visited were those suggested by Dr. Dart and Mr. McCook as being probable breeding areas. No attempt was made at a systematic examination.

THE FRESH WATER PROBLEM.

Dodge Pond. A large fresh water pond situated a short distance west of Niantic village. The pond is partially divided into two sections. The small western section near the road is covered with lily pads, and owing to the unusual season is dry at this time. This drying up must have been gradual, leaving

numerous small pools in the uneven muddy bottom which were ideal breeding places for fresh-water mosquitoes, including *Anopheles*. Stones have been dumped along the shallow edge and are overgrown with low bushes and weeds. Mosquito breeding must take place along this edge at all times during a normal season. The large easterly portion of the pond contains water and is stocked with fish. While this part of the pond was not examined, there is much brush along the edge and the conditions are probably similar to those of the small pond.

To make Dodge pond safe I would suggest that the edge be made more abrupt by filling and that any brush growing near the edge in the water be removed, so as to insure a clean edge with no small pools that cannot be visited by small fish.

The *Pataguanset River*, west of the road at this point, was examined for a short distance. This stream has clean edges and should be free from mosquito breeding. About one hundred feet west and parallel to the river is a swampy area, apparently without good drainage. Draining this into the river would do away with a possible *Anopheles*-breeding area.

Middle Pond. This pond at Crescent Beach was examined. A driveway cuts it off from the salt water, but a large drain extends under the driveway, through which, I was told, the tide comes in. I was afterwards informed that there is a gate in the drain keeping the tide out and that the pond contains fresh water. Fish were numerous and no mosquito larvae were observed. If this is maintained as a fresh-water pond the edge should be watched more carefully than would be necessary if it was washed by the tide.

Lower Pond. A large fresh-water pond south from Middle pond. At the north end is a cat-tail and sphagnum swamp extending northward and then easterly around an area of higher land called the "Island" (?) and connecting with the Middle pond. The edge around the rest of Lower pond is clean and in good condition. A portion of the swamp along the east side was examined and no suspected breeding places were observed. Where the driveway crosses this swamp to reach the "Island" is a bridge over a small ditch which extends into the Middle pond. The ditch has long been neglected and consists merely of a series of small pools which were found to contain larvae of *Culex*. This drain should be opened at least from the bridge

to the Middle pond. This would drain the low area east of the bridge, which is now in a soggy condition.

This section should be examined in a normal season to best judge the conditions.

THE SALT MARSH PROBLEM.

The east side of the Pataguanset marsh from the railroad south was viewed from the road and a section at the lower end was examined. Most of the small pools contained fish or were reached by the tide. No mosquito larvae were found.

The marsh on both sides of the bridge where the Old Black Point road crosses the Pataguanset river was examined. On the south side of the bridge and east of the river the marsh is in a very soggy condition. The old ditches are choked and there are numerous pools of standing water, nearly all containing large number of wrigglers of the salt marsh mosquito, *Culex sollicitans*. A short distance from the bridge a small point of the marsh extends inland. This area contains a number of depressions where the water has dried out, and the mud is covered with dead larvae. This place would probably be more serious in a normal season. It could be drained by cleaning out an old ditch which extends towards this point from the river, and continuing it for about one hundred and fifty feet. This marsh should be examined southward as far as the railroad, and where breeding is found ditches should be dug to the river.

The east side of the river north of the bridge is also in a serious condition and needs ditching. Many pools with a large number of larvae were found here. Further to the north the marsh extends around a point of land and reaches nearly to the road. This area contains several large pools with very few fish in them. Mosquito larvae were present in great numbers. An old choked ditch extending in from the river is not connected with any of these pools. It should be cleaned and extended for about one hundred feet. It will probably be necessary to dig two or three lateral ditches on each side of this main ditch to drain the area. The marsh west of the river was not examined but appears to be in a similar condition to that on the east side.

The ditches recommended for draining this marsh should be from six to twelve inches wide and about two feet deep. Good drainage should be secured by placing the ditches one hundred feet apart. Without taking any measurements, I should judge that about one thousand feet of ditch would be required to drain the area examined. There are already a few ditches which could be cleared and deepened. Probably a good laborer could put the area in a safe condition in about eight or ten days.

The mosquito larvae found in these various pools were about full-grown, and to destroy these I would recommend the use of kerosene oil. This can be applied with a watering pot having a fine rose.

Mr. McCook soon oiled the worst areas, with satisfactory results, but no draining was attempted. It is usually possible, by the expenditure of moderate sums of money in draining and filling, to do away with the wholesale breeding of mosquitoes. The inhabitants of each neighborhood should coöperate to make the locality as attractive as possible—and one of the first things to be done in each settlement along the Connecticut coast is to abolish the pools of stagnant water where mosquitoes breed. If permanent ditching cannot be started, oiling the pools will afford temporary relief, but in order to be effective it should be repeated once in ten days or two weeks during the mosquito season.

THE CHEMICAL COMPOSITION OF LEAD ARSENATE AND PARIS GREEN.*

BY JOHN PHILLIPS STREET.†

The constantly increasing use of insecticides in various spraying mixtures makes the effectiveness and the cheapness of the poisons used a matter of considerable practical importance. Paris green has been more commonly used for many years than any other arsenical insecticide, and has proved very effective. There is, however, a certain serious objection to its use; the partial

* This paper, with the directions following it by Mr. Britton, was printed as Bulletin 157 and distributed in September. It is here placed in more permanent form with slight emendations.

† The analyses of Paris green have been made by Messrs. E. M. Bailey and E. J. Shanley; those of lead arsenate by the writer.

solubility in water of the arsenious oxide, which frequently causes damage to foliage. For this reason entomologists have sought a different poison, which would be effective against insects, harmless to plants, and economical for the farmer to use. Lead arsenate seems to meet these requirements, and possesses a still further advantage over Paris green in that its mechanical condition keeps it longer in suspension in the spraying mixture. There are a number of brands of this material on the market, varying greatly in appearance and consistency, and it was considered advisable to make a somewhat extended chemical examination of them to determine their relative value. As the various brands of Paris green on sale in this State had never been analysed at this station, they also have been included in this examination.

METHODS OF ANALYSIS.

In the analysis of lead arsenate the method proposed by Haywood* has been followed in all particulars, and has proved very satisfactory. With Paris green the same methods as used by the writer† in a similar examination at the New Jersey Station have been followed. In addition, however, a test of the water-solubility of the arsenious oxide was made by the official A. O. A. C. method,‡ treating the green with distilled water for ten days.

LEAD ARSENATE.

Ten of the eleven samples analysed were taken from the museum stock of Dr. Britton, the State entomologist, but were recently acquired and were believed to be representative; the duplicate sample of Swift's arsenate was bought in the open market. The samples were received in containers of various sizes and material, from a one-pound glass jar to a fourteen pound wooden bucket. The material itself showed striking differences in consistency. Disparene settled out completely, leaving a supernatant liquid filling from one-fourth to one-third of the vessel; the Target brand and Swift's also showed some separated liquid, while the others were more of the consistency of putty and quite homogeneous.

The samples analysed were as follows:

* U. S. Dept. of Agr., Bur. of Chem., Bull. 105, 165.

† New Jersey Expt. Station, Bull. 195.

‡ U. S. Dept. of Agr., Bur. of Chem., Circ. 10, 3.

19210. Eagle Brand. Adler Color & Chemical Co., New York.

19212. Target Brand. American Horticultural Distributing Co., Martinsburg, W. Va.

19211. Disparene. The Bowker Insecticide Co., Boston, Mass.

19216. Star Brand. Fred. L. Lavanburg, New York.

19215. Anchor Brand. Leggett & Bro., New York.

19213. Swift's Arsenate. Merrimac Chemical Co., Boston, Mass.

18703. Duplicate of No. 19213, purchased in market.

19643. Arsenate of Lead. Monmouth Chemical Works, Shrewsbury, N. J.

19357. Arsenate of Lead. The Powers-Weightman-Rosengarten Co., Philadelphia, Pa.

19358. Aiboneta. Schoonmaker & Son, Cedar Hill-on-Hudson, N. Y.

19209. Arsenate of Lead. The Vreeland Chemical Co., 123 Maiden Lane, New York. (Factory at Little Falls, N. J.)

ANALYSES OF ARSENATE OF LEAD.

Station No.	Brand.	Original Material.						Water-Free.		
		Water.	Arsenic Oxide (As ₂ O ₅).	Lead Oxide (PbO).	Soluble Impurities (other than As ₂ O ₅ and PbO).	Insoluble Impurities (by difference).	Soluble Arsenic Oxide.	Arsenic Oxide (As ₂ O ₅).	Lead Oxide (PbO).	Total Impurities.
19210	Eagle	54.55	14.89	28.46	0.32	1.78	0.46	32.76	62.62	4.62
19212	Target	50.30	12.30	34.03	2.73	0.64	1.31	24.75	68.47	6.78
19211	Disparene	46.47	13.87	35.11	4.34	0.21	0.39	25.91	65.59	8.50
19216	Star	50.57	12.64	35.63	0.47	0.69	0.51	25.57	72.08	2.35
19215	Anchor	35.59	17.11	44.05	2.02	1.23	0.86	26.56	68.39	5.05
19213	Swift's	49.95	14.91	33.08	0.80	1.26	0.57	29.79	66.00	4.12
18703	"	48.40	15.19	33.78	0.88	1.75	0.30	29.44	65.47	5.09
19643	Monmouth	58.44	11.29	25.59	1.41	3.27	0.50	27.17	61.57	11.26
19357	Powers-Weightman	51.79	11.42	33.70	2.69	0.40	0.22	23.69	69.90	6.41
19358	Aiboneta	41.95	11.72	37.90	7.94	0.49	0.42	20.19	65.29	14.52
19209	Vreeland	33.65	21.91	41.44	0.74	2.26	0.86	33.02	62.46	4.52

RESULTS OF ANALYSES.

The analyses show lead arsenate to be far from a uniform material; the arsenic oxide ranges from 11.29 to 21.91 per cent.,

and the lead oxide from 25.59 to 44.05 per cent. The soluble arsenic oxide was low in all cases, ranging from 0.22 to 1.31 per cent., and this after a treatment for ten days. No soluble lead oxide was found in any of the samples. The nature of the impurities was not determined in any case; **19210**, **19358**, **19643** and **19357**, however, showed traces of nitrates. The impurities were not high except in three samples, **19211**, **19643** and **19358**; neither Disparene nor Aiboneta was sold as pure lead arsenate and therefore cannot be considered adulterated; the Monmouth sample, however, was sold as a pure material; in addition to its high content of impurities, it also contains the lowest percentages of both arsenic and lead oxides.

Lead arsenate is usually prepared by the action of lead acetate on disodium arsenate; some manufacturers, however, substitute lead nitrate for the acetate. Smith* has shown that the commercial grades of sodium arsenate and lead acetate and nitrate vary considerably. He found the lead oxide in lead acetate varied from 58.81 to 66.80 per cent., and in lead nitrate from 66.37 to 68.37 per cent.; while in sodium arsenate the arsenic oxide varied from 36.77 to 47.80 per cent. The calculation of the theoretical composition of commercial lead arsenate is, therefore, attended with some difficulty. Haywood,† however, has shown that, with pure chemicals, where lead acetate is used the theoretical composition should be 74.40 per cent. lead oxide and 25.60 per cent. arsenic oxide; and where lead nitrate is used, 64.26 and 33.15 per cent., respectively. The methods used in the above analyses give results very close to theory where the lead arsenate is prepared from lead nitrate, but where lead acetate is used slightly higher than theory for arsenic oxide and slightly lower for lead oxide, indicating that probably some secondary reaction takes place during the process of manufacture, resulting in the formation of some compound other than lead arsenate, probably an acid lead arsenate. By referring to the analyses of the samples on the water-free basis, it appears that **18703**, **19209**, **19210**, **19213** and **19643** are made from lead nitrate, the others from lead acetate. Formerly it was the practice to add glucose to increase the adhesive power of the arsenate, but it has been shown that it adheres almost as well without glucose as with it, and its use has been largely discontinued.

* Agr. Massachusetts, 1897, 357-369.

† U. S. Dept. of Agr., Bur. of Chem., Bull. 105, 163.

Allowing for the variations in process of manufacture, it would seem, however, that the content of arsenic oxide in the various commercial lead arsenates was conditioned more by the wetness of the material than anything else; the content of water in the samples analysed ranged from 33.65 to 58.44 per cent. A perfectly dry material has not been found advantageous, for while even in such a form it remains in suspension several times as long as the finest Paris green, it settles about three times as fast as when the arsenate is used in the form of a paste. On the other hand, the paste must not be too tenacious or it will be difficult to break up and distribute evenly throughout the spraying mixture. Colby* has found this objection to hold with Disparene. In making the water-soluble determinations it was observed that there were marked variations in the rate of settling even when the samples were in the dry and powdered condition. It is probable that the same peculiarity would have been noted in the samples in their original state, but as in most cases the whole sample had already been dried, verification of this supposition was impossible.

HOME-MADE LEAD ARSENATE.

It has frequently been recommended that farmers prepare their own lead arsenate as they need it. Colby† recommends the following formula: Dissolve 24 oz. of lead acetate or 20 oz. of lead nitrate in one gallon of cold water; also separately dissolve 10 oz. sodium arsenate in three quarts of water, both solutions to be made in wooden vessels. Pour the separate solutions into the spray tank containing from 100 to 150 gallons of water; a white precipitate of lead arsenate immediately forms. This preparation may be made several times stronger without the least danger of injury to the foliage. The freshly precipitated home-made arsenate seems to keep in suspension better than even the best commercial preparations.

COST OF LEAD ARSENATE.

As stated before, only one of the samples was bought in the open market; the prices have therefore not been affixed in any case. By correspondence with the manufacturers the Station

* California Expt. Station, Bull. 151.

† Loc. cit.

received quotations as follows: In 100 lb. kegs, from 9.5 to 13 cents per lb.; in 5 to 20 lb. buckets, from 11 to 16 cents per lb.; and in 1 lb. cans from 11.5 to 17 cents per lb. The advantage of purchasing in quantity is apparent.

ITS ADVANTAGES.

Lead arsenate is very effective against leaf-eating insects. Its chief advantages over Paris green are its greater adhesive power and its harmlessness to the foliage. A single treatment of lead arsenate will adhere to the foliage for a period during which two or three sprayings with Paris green would be necessary to secure the same effect. The insolubility of its arsenic makes possible the use of large quantities without danger even in inexperienced hands. From the standpoint of effectiveness lead arsenate, although containing but from one-third to one-fourth as much actual arsenic as Paris green, is nearly as economical as the latter poison when sold at the same price. Purchased at the wholesale quotations noted elsewhere, and considering the duration and safety of its action, it is actually somewhat cheaper than Paris green. Furthermore, its greater power of suspension makes it more easily used and insures a more uniform distribution of the poison over the plant.

PARIS GREEN.

There is no law in this State regulating the sale of Paris green, but where a state inspection is in effect the requirements are generally very similar to those in the New Jersey law,* section 3 of which reads:

"Paris green, or any product analogous to it, when sold, offered or exposed for sale as such, in this State, shall comply with the following requirements:

"First. It shall contain arsenic, in combination with copper, equivalent to not less than fifty per centum arsenious oxide.

"Second. It shall not contain arsenic in water-soluble forms equivalent to more than three and one-half per centum of arsenious oxide."

Many analyses of Paris green have been made by the various Experiment Stations, showing the green to be of variable composition. These variations are chiefly due to different methods of manufacture or carelessness in carrying out the same. In many cases a large amount of the arsenic exists as free arsenious

* New Jersey Expt. Station, Bull. 195.

oxide, which may arise from intentional addition of white arsenic, as well as from careless manufacture. This is a serious adulteration, for white arsenic is a cheaper material, and its solubility in water renders its presence in anything but small quantities a source of much danger to foliage from scorching. Other adulterations have been detected, but the one just referred to is the most prevalent and most objectionable.

Paris green is essentially copper aceto-arsenite, and, if pure, should contain an equivalent of 58.65 per cent. arsenious oxide, 31.29 copper oxide and 10.06 acetic acid. The commercial article, however, usually contains small quantities of moisture and sand and varying amounts of sodium sulphate.

Twelve samples, representing eight manufacturers, were purchased from dealers by the Station sampling agent. A description of these follows:

19481. Made by A. B. Ansbacher & Co., New York. Sold by Lyon & Ewald, New London.

18662. Made by A. B. Ansbacher & Co., New York. Sold by the Sisson Drug Co., Hartford.

18634. Made by E. J. Barry, New York. Sold by Odell's Pharmacy, New Britain.

18509. Made by E. J. Barry, New York. Sold by J. H. & W. E. Cone, Hartford.

18704. Made by James A. Blanchard, New York. Sold by F. S. Platt, New Haven.

19547. Made by Morris Hermann & Co., New York. Sold by D. B. Wilson Co., Waterbury.

18569. Made by Leggett & Bro., New York. Sold by Lockwood & Palmer, Stamford.

18508. Made by Leggett & Bro., New York. Sold by M. H. Mallett, New Milford.

18512. Made by I. Pfeiffer, New York. Sold by Frank M. West, Bridgeport.

18510. Made by C. T. Reynolds & Co., New York. Sold by H. K. Brainard, Thompsonville.

18511. Made by C. T. Reynolds & Co., New York. Sold by Danbury Hardware Co., Danbury.

18663. Made by The Sherwin-Williams Co., Newark, N. J. Sold by R. E. Page, Hartford.

ANALYSES OF PARIS GREEN.

Station No.	Manufacturer.	Cost of Package.	Weight of Package.		Arsenious Oxide. (As ₂ O ₃).				
			Claimed.	Found.	Total.	Water-Soluble, 1 day.	Water-Soluble, 10 days.	Copper Oxide. (CuO).	Arsenious Oxide combined with copper.
		cts.	oz.	oz.	%	%	%	%	%
19481	Ansbacher	13	* 4	3.6	57.92	1.46	2.92	28.76	53.78
18662	"	10	4	4.0	57.44	0.97	2.44	29.49	55.15
18634	Barry	35	*16	14.5	57.23	1.71	6.82	29.55	55.26
18509	"	18	* 8	8.0	56.62	2.44	6.82	29.01	54.25
18704	Blanchard	10	4	5.0	57.03	2.44	7.31	28.14	52.62
19547	Hermann	18	* 8	7.6	56.20	2.44	4.87	28.54	53.37
18569	Leggett	10	* 4	3.6	60.61	5.85	10.72	27.15	50.77
18508	"	20	8	7.3	56.83	2.92	8.77	29.34	54.87
18512	Pfeiffer	20	8	8.0	56.71	1.46	4.38	30.27	56.60
18510	Raynolds	28	*16	15.4	60.83	1.95	6.32	26.56	49.63
18511	"	10	* 4	4.0	61.19	2.44	9.74	27.15	50.77
18663	Sherwin-Williams	10	4	3.6	56.56	1.46	2.92	29.88	55.88

All the samples were carefully weighed with and without the container; one sample was overweight, four equalled the weight claimed, and seven were short weight. These shortages varied from 4 to 10 per cent., not large in any case, but indicating that the manufacturers' claimed weight is intended to include the weight of the container as well as the green itself, a practice without justification.

CHEMICAL ANALYSIS.

Total Arsenious Oxide. All the samples contained satisfactory amounts of total arsenious oxide, varying from 56.20 to 61.19 per cent. with an average of 57.93 per cent.; this average is only slightly lower than the equivalent of arsenious oxide contained in pure copper aceto-arsenite. Judging, therefore, alone from the content of arsenious oxide, it would appear that the Paris green on the market in Connecticut is of high quality. A definite decision as to the purity of the green, however, cannot be reached without considering also the amount of water-soluble arsenic present.

Water-Soluble Arsenious Oxide. Free arsenious oxide is always soluble in water, and the combined arsenic is liable to be

* Weight printed on label; in all other cases the weight is assumed from the size of package and price asked.

rendered soluble by prolonged treatment. Two methods for determining soluble arsenious oxide have been adopted provisionally by the Association of Official Agricultural Chemists, in one of which sodium acetate is used as the solvent, while in the other the green is treated with water for ten days. Investigations with these methods have shown that the sodium acetate method gives more closely the true percentage of free arsenious oxide, while the water-extraction method gives in addition some arsenic caused by the decomposition of the green by water. From a practical standpoint the portion of the green that is so loosely combined would in all likelihood soon break up and scorch the foliage quite as badly as would free arsenious oxide. The water-extraction method would seem, therefore, to indicate more accurately the probable effect of the green on foliage.

The provisional method of the A. O. A. C. requires treatment with water for ten days, but it has been pointed out that the usual practice among horticulturists is to mix the green with water not very long before they wish to use it. For this reason certain Stations, for instance New York, California and New Jersey, have adopted a one-day extraction period, which it is believed gives results more in harmony with actual practice. This Station has likewise adopted this method in the present work, and analyses by both the one-day and ten-day extractions are given in the table for comparison. The analyses clearly show that, if the ten-day method is to prevail as a standard, but three of the samples would fall within the usual legal limit of three and one-half to four per cent. of soluble arsenious oxide. With the one-day method, but one sample, **18569**, contains an excessive amount, 5.85 per cent. This sample varies greatly in composition from a duplicate sample from the same manufacturer, and under the microscope clearly shows the presence of white arsenic. The use of this sample would be exceedingly dangerous to foliage.

Copper Oxide. The amount of cupric oxide found in the samples varied from 26.56 to 30.27 per cent., with an average of 28.65 per cent. In pure copper aceto-arsenite the ratio of arsenious oxide to copper oxide is as 1.87 is to 1.00. This ratio is of value in assisting to determine whether white arsenic has been used to fortify the green, for arsenious oxide cannot be added without increasing the ratio. In the samples analysed, the ratio

varied from 1.87 to 2.29; the high ratio shown in sample 18569 gives additional evidence of the presence of considerable quantities of white arsenic. The amount of arsenious oxide in combination with copper varied from 49.63 to 55.88 per cent., with one exception above the usual legal requirement of 50 per cent. In three of the samples the amount of arsenious oxide is more than 2.20 times that of the copper oxide, and the natural inference is that either arsenic has been added purposely or that the material has been carelessly manufactured.

A comparison of the water-soluble arsenic in Paris green and lead acetate emphasizes one of the chief advantages gained by using the latter insecticide. In lead arsenate from 0.22 to 1.31 per cent. was soluble in ten days, while in Paris green the solubility ranged from 2.44 to 10.72 per cent.

DIRECTIONS FOR THE USE OF LEAD ARSENATE AND PARIS GREEN AS INSECTICIDES.

Lead arsenate as an insecticide was first used in the work of the Gypsy Moth Commission in Massachusetts in the early nineties and it has since been employed in controlling nearly all of the leaf-eating insects, and has proved to be a valuable addition to our list of available arsenical poisons. When devoured by insects it is somewhat slower in its action than Paris green, and should therefore be applied earlier, before much damage has been done to the plants. On account of the excellent adhesive qualities of lead arsenate, it remains upon the foliage for a long time, while Paris green soon washes off if rains are frequent. Lead arsenate is gradually replacing Paris green as an arsenical insecticide, and especially during the past season the high price of the latter has induced many farmers and fruit growers to use lead arsenate. Paris green has been used to destroy leaf-eating insects ever since the Colorado potato beetle reached the Atlantic States. It is therefore the old standard remedy, and in many places is the only arsenical insecticide that can be purchased at the stores.

FORMULA FOR LEAD ARSENATE.

As lead arsenate is sold in paste form, and even when calculated as water-free contains less arsenic than Paris green, it is necessary to use a larger quantity by weight of the commercial

article to gain the desired end in spraying work. Lead arsenate can be used only in liquid form to be sprayed upon the foliage, and the usual formula is as follows:

Lead arsenate.....	3 lbs.
Water.....	50 gallons.

For sawfly larvae and some other insects that are easy to kill, one pound in fifty gallons may suffice, and in spraying to kill gypsy caterpillars five pounds in fifty gallons are the proportions considered the most effective. In spraying for elm leaf beetle larvae the poison should be directed against the under sides of the leaves. The amount of lead arsenate may be increased greatly without danger of injuring the foliage, and lime should not be added. Lead arsenate can be used in connection with Bordeaux mixture, though it is thought to be slightly less effective as an insecticide when used in this way.*

FORMULA FOR PARIS GREEN.

Paris green is put up in powder form and can be applied either dry or as a liquid. On account of the soluble acid which it contains (see page 328 of this report) there is always danger of "burning" the foliage unless some alkali is used with the poison. For this purpose lime is usually recommended, and the adhesiveness of the mixture is greatly improved by the lime. About three pounds of lime should be used for each pound of Paris green. If to be applied dry in a duster or powder gun, Paris green should be mixed thoroughly with air-slaked lime or land plaster in the following proportions:

Paris green	1 pound.
Air-slaked lime	100 pounds.

For use as a spray Paris green may be prepared as follows:

Paris green.....	1 pound.
Fresh quicklime	3 pounds.
Water	100 gallons.

In most orchards and potato fields Paris green is used in connection with Bordeaux mixture, and as this contains an excess of lime, no more lime is added.

* Tests made at this Station show that the presence of the Bordeaux mixture renders the lead arsenate perfectly insoluble. This perhaps may account for its lessened poisonous effect on insects.

THE HICKORY TUSSOCK MOTH.

Halisidota caryae Harris.

During the past two years this insect has been unusually abundant in Connecticut, and leaves of fruit and shade trees were eaten by the caterpillars. Late in the fall, solitary caterpillars nearly full-grown were found feeding upon the leaves of nursery, orchard and shade trees. I have not before seen this species so abundant during a residence of nearly fourteen years in Connecticut.

The eggs are laid early in June on the under side of a leaf in the form of a broad patch about an inch in diameter. The caterpillars are very small and gregarious at first, and may be easily mistaken for the larvae of the fall web-worm or several other species. As the larvae increase in size they take on characteristic markings with each molt, until next to the last molting stage they are very striking and pretty caterpillars, being covered with white hairs ornamented with spots of black. Near each end of the body there are two pencils of long black hairs and several tufts of long pure white hairs showing at both ends and along the sides of the body. Plate XV, a. shows this stage of the caterpillars, natural size. In the last caterpillar stage (see Plate XV, b.) the larva has a black stripe on the back, with the four pencils of black hairs as described above. The other hairs are white. The caterpillar is one and one-half inches long, and is very conspicuous and striking in appearance.

When fully grown it crawls under stones, fence rails, or into some other out-of-the-way corner, and spins a few silken threads, which together with its own hairs form a thin ash-grey cocoon, oval in shape, nearly an inch long and about one-half as thick. The cocoon is shown on Plate XV, c.

The adult moth measures nearly two inches from tip to tip of wings, and is shown on Plate XV, d. The fore wings are light brown, irregularly spotted with white and with darker lines along the veins. The rear wings are white.

Wherever the caterpillars are so abundant as to defoliate trees, the proper remedy is to spray with the arsenical poisons, either arsenate of lead or Paris green, according to the formulas given on page 331 of this report.

THE ROUND-HEADED APPLE BORER.

Saperda candida Fabr.

Young apple trees are often attacked at the base and seriously injured by borers. Even large trees are attacked, but do not become devitalized and show the effects of the work of the borer like the younger and smaller trees. Especially if the young orchard be isolated and surrounded by woodland is the attack liable to be severe.

Two kinds of borers are responsible for this kind of injury to trees,—the round-headed borer, *Saperda candida* Fabr., belonging to the family Cerambycidae, and the flat-headed borer, *Chrysobothris femorata* Fabr., which belongs to the family Buprestidae. The former is much more common in Connecticut, and we believe is the chief species attacking fruit trees. Neither species is confined to orchard trees, but lives in various native trees of the fields and woodlands, the round-headed borer being especially fond of the wild thorn, mountain ash, shad bush and chokeberry, and the flat-headed species attacking many of the larger shade and forest trees.

The round-headed apple borer is found throughout the United States and Canada, at least east of the Rocky Mountains. The adult is a long-horned beetle about three-fourths of an inch long, dark grey or brownish, with two straight white stripes or bands on the back running lengthwise of the body. These bands are not quite parallel, but join on the head and are furthest apart at the base of the wing covers, coming near together again at the apex. The antennae, legs and front of the head are white. The antennae are long and slender, as is characteristic with this family of beetles. This insect, with its characteristic injury, is shown on Plate XVI.

The eggs are yellow or pale brown, three times as long as broad and three times as broad as thick, and about one-eighth of an inch long. They are laid in incisions in the bark made by the ovipositor of the adult female, the eggs being placed lengthwise the trunk. The adults appear in June, July and August, most of the specimens in the station collection being taken in June. In Connecticut, therefore, the eggs are laid during these three months. The young borer tunnels just under the bark,

working downward as far as possible before winter. Though inactive during the cold weather, it again begins operations in the spring, and burrows in the sapwood throughout the season, becoming about half-grown by the second winter. As it increases in size it does more and more damage to the tree because it is more voracious and active and makes larger tunnels through the wood. The next summer, when about three-fourths grown, it tunnels into the solid wood of the tree, and as it becomes full-grown works its way outward to the bark, making a circular hole as shown on Plate XVI. Remaining in the burrow unchanged through the winter, the larva transforms to a pupa in the spring and the beetle appears during the summer. About three years are therefore required for the complete transformations of this insect. Where several larvae are at work in the same tree they often girdle and kill it. The larva is white, with brown head and black jaws, and is about one inch long when full-grown. Usually the burrows are partially filled with particles of wood or castings from the excavations, and the pupating chamber is made of this material. Some of the castings are crowded or thrown out of the burrow, and form the principal evidence of the presence of the insect. This beetle and its work is shown on Plate XVI, where about twenty large galleries were made in the wood of the trunk of a quince tree.

Many remedies have been tried but most orchardists prefer to watch their trees and dig out the borers with a knife when found. Sometimes carbon bisulphide can be injected into the burrow from an oil can and the opening stopped with clay, soap, or wax, and the borer inside will be killed. External washes and other applications are of somewhat doubtful value, and the painting of the trunks is liable to cause great injury to the trees. Covering the base of the trunk with arsenate of lead may be of some value in keeping out borers, but this has not yet been thoroughly tested. It will adhere for a long time.

MISCELLANEOUS INSECT NOTES.

Pine Leaf Scale on Hemlock. On October 23d the writer examined a hemlock tree on the estate of the late J. M. Greist in Westville which was said to be dying. Several branches on

the south side of the tree were dead and leafless. Otherwise the tree appeared perfectly vigorous and the foliage was of a dark green color. Finally a few leaves were observed that did not look quite healthy, and they were found to be infested with the pine leaf scale *Chionaspis pinifoliae* Fitch. Some branches were considerably infested, and the dead ones may have been killed in this way. It was certainly difficult to find any other explanation. This insect was mentioned in Bulletin 151, page 11, and in the report for 1905, page 240, and shown on Plate II, c. It resembles the scurfy scale, and is found on the leaves of pine and spruce trees. It is becoming rather common in Connecticut, and has been observed on white pine seedlings at Windsor the past season. It has also been sent in from various parts of the state on other species of pines from cultivated grounds. I have seen no record of its occurrence on hemlock. The remedy is to spray with kerosene emulsion soon after the eggs hatch.

Willow Curculio. In Massachusetts, New York and Minnesota the willow curculio, *Cryptorhynchus lapathi* Linn., causes considerable injury to ornamental willow and poplar trees in parks and on private grounds. Previously, however, the insect has not been very common in Connecticut. On July 7th, 1905,



FIG. 5.—The willow curculio, twice natural size.

the writer collected a specimen of this beetle from a bunch of native willows (*Salix discolor*) at Torrington. The willows had been tunneled through and through by this insect, and though of no value, were ruined. In 1906, another species of willow at Guilford was observed to be likewise injured by this beetle. During 1907 several bunches of willows near New Haven have been killed outright by its attack. This beetle is one of the snout beetles or curculios, and is shown in Figure 5.

The Poplar Borer. While engaged in cutting and pruning trees to control the gypsy moth in Stonington, the men came across a poplar tree showing serious injury by borers. Chips or castings were falling from large galleries in the wood of the trunk. As the tree was of no value and was in such shape as to be a hindrance, it was removed. A section of the trunk was placed in a breeding cage and during August several specimens of the poplar borer, *Saperda calcarata* Say, emerged from the galleries and were killed and mounted for the collection. This beetle is one of the long-horned beetles closely related to the round-headed apple borer, and is of a mouse-grey color with yellow stripes and spots on the thorax and wing covers, and with fine black dots sprinkled over the wing covers. It is about an inch in length.

The Maple Borer. This insect, which is closely allied to the preceding, is causing serious damage to maple shade trees in Connecticut. A large proportion of the street trees in the cities and villages, as well as the shade trees along the country roads, show injury caused by this insect. The maple borer,



FIG. 6.—The maple borer, natural size.

Plagionotus speciosus Say, is a handsome black beetle with yellow markings, and is about an inch long. It is shown in Figure 6. The insect was studied many years ago, and the evidence gathered showed that three years are necessary for the species to develop from the egg to the adult stage, but the subject should again be investigated. The beetles emerge here usually about the first half of July, and probably soon lay their

eggs. The trees should be examined in the fall for the fine castings thrown out by the small larvae. Constant watching is the only safeguard, and where found, carbon disulphide will kill the insect if the burrow is stopped up so that the fumes cannot escape.

The Grape Vine Flea-Beetle. Beetles were received from Plantsville and from Danbury about the middle of May with reports that they were causing injury by eating holes into the buds, which had not then opened. This is a small dark blue beetle bearing the Latin name of *Haltica chalybea* Ill. Covering the buds with an arsenical poison like Paris green or lead arsenate will prevent injury.

The Elm Leaf Beetle. (*Galerucella luteola* Müll.) This insect was less abundant than in 1906, though made the subject of Bulletin 155, which was issued in May, 1907. This bulletin is not reproduced in this report, but will be sent to any address on application as long as the supply lasts.

An Injurious Myriapod. Specimens were received from Guilford and from North Haven of a small Myriapod or "thousand-legged worm" that had been feeding upon the roots of plants, causing considerable injury. At Guilford large buds of hardy bulbs had been attacked and destroyed by them. I have similar records of injury by this same species from Woodbridge and from Massachusetts. It was identified as *Julus hortensis* Wood, a species known to injure various plants, but apparently no experiments have been made with remedies and the literature contains few suggestions as to treatment.

A Fungus-Inhabiting Beetle. On December 7th a beetle was received from Watertown with the statement that it was found crawling about in the house. The beetle was *Boletotherus bifurcus* Fabr., a species known to inhabit shelf fungi which grow upon trees and logs. Probably a piece of fungus on fuel was brought into the house and the insect emerged from it.

The Bag-worm. This name is erroneously given to the common Tent caterpillar by many persons. The bag-worm *Thyri-*

dopteryx ephemeriformis Steph. is an entirely different insect and is much more common in the southern states than here. Nevertheless it occurs here and is occasionally found feeding upon arbor vitae in the shore towns. Specimens of larvae with their bags of cases attached to fence posts were received from Cheshire.

The Rabbit Bot-fly. In September we received from Southport, large larvae which had been found under the skin of a rabbit below the neck. Though not familiar with this parasite I consulted Professor Osborn's paper on "Insects Infesting Domestic Animals" * and found that the larvae agreed with the description and figures of the rabbit bot-fly, *Cuterebra cuniculi* Clark.

* Bulletin 5, new series, Division of Entomology, U. S. Dept. of Agriculture, page 108, 1896.

ILLUSTRATIONS.

The illustrations in Part V of this report are from the following sources:

Plate XV a, from photograph by D. B. Pangburn.

Plates VII, VIII b, IX c, X, XI, and XII from photographs by G. H. Hollister.

Plates VIII a, XIII b, XIV a, XV b, c and d from photographs by W. E. Britton.

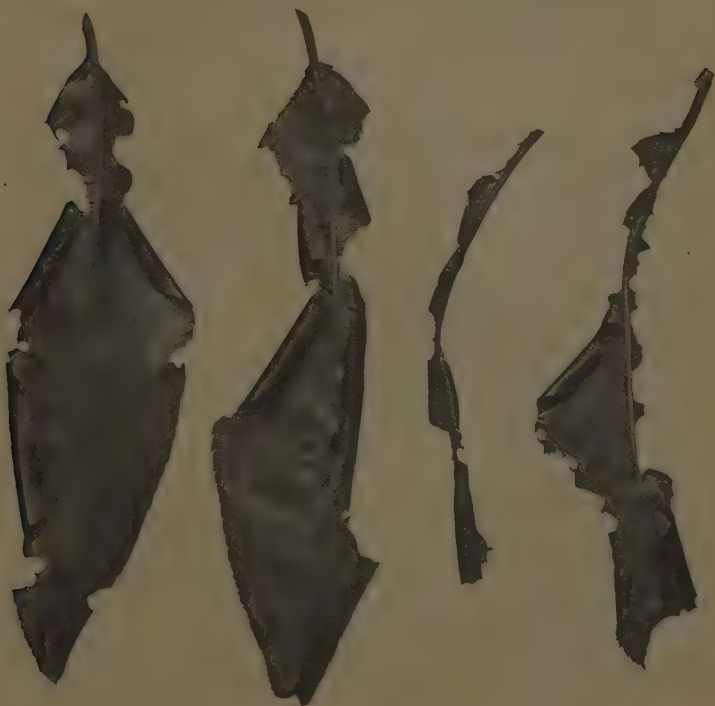
Plate III b from drawing, and all other plates from photographs by B. H. Walden.

Text figures 1, 2, 3 and 4 are from Fernald, Special Bulletin Massachusetts Agricultural Experiment Station, 1897.

Figures 5 and 6 are from drawings by W. E. Britton.



a.—Twig partially defoliated by the larvae.

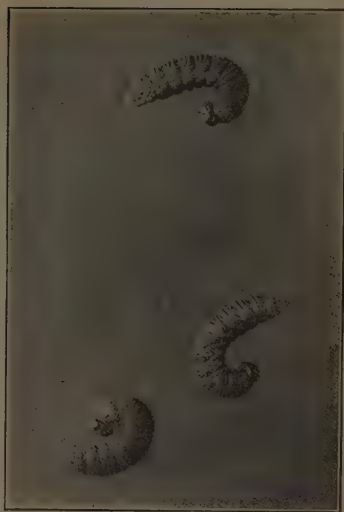


b.—Leaves eaten and rolled by the larvae. Natural size.

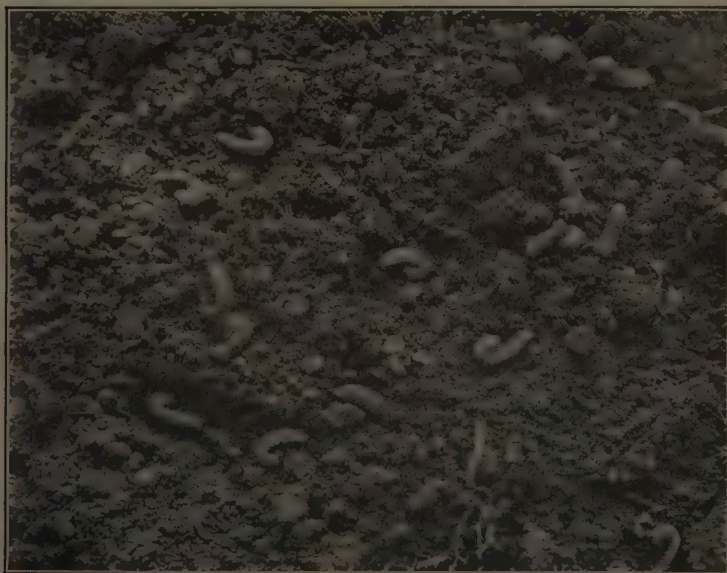
WORK OF THE PEACH SAWFLY.



a.—Eggs on the under-side of peach leaves. Natural size.

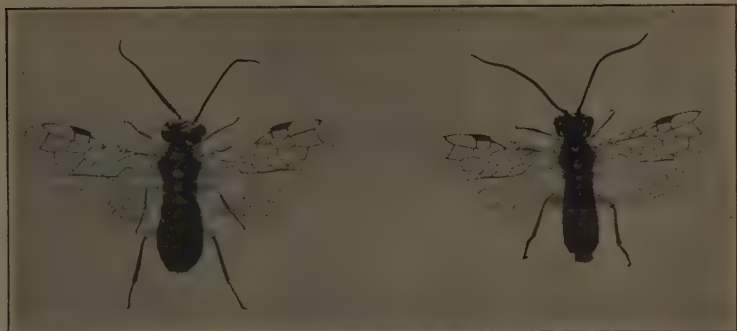


b.—Larvae. Twice natural size.

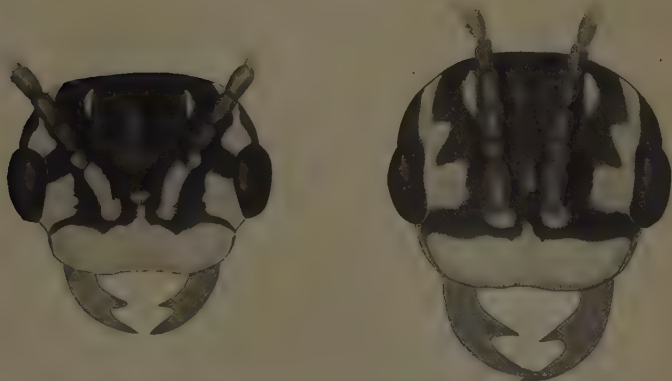


c.—Larvae taken from ground in spring. Natural size.

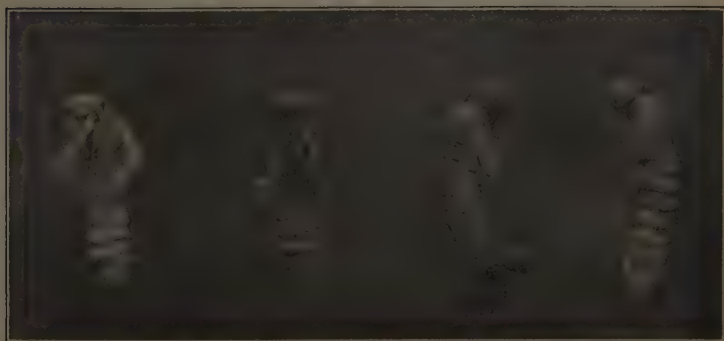




a.—Adults, female at left. Twice natural size.



b.—Facial markings of the sexes, male at left. Greatly enlarged.



c.—Pupae. Twice natural size.





HOLES IN GROUND WHERE ADULT SAWFLIES HAVE EMERGED. NATURAL SIZE.



a.—General view of breeding cages.



b.—A near view showing side of breeding cage raised.

BREEDING CAGES USED IN PEACH SAWFLY EXPERIMENTS.



a.—Spraying peach trees with arsenate of lead and water.



b.—A peach tree partially defoliated.

SPRAYING PEACH TREES, AND VIEW OF DEFOLIATED TREE.



a.—Scouting for egg-masses.



b.—Treating an egg-mass with creosote.

DESTROYING GYPSY MOTH EGG-MASSSES.



a.—Two views in Stanton orchard. Pruning trees and painting wounds.



b.—Thinning the top.

GYPSY MOTH WORK: PRUNING TREES.



a.—Gang of workmen cutting brush.



b.—Brush area cleaned up.

GYPSY MOTH WORK: CUTTING BRUSH.



a.—Woodpile in which seven egg-masses were found.



b.—Method of applying burlap band.

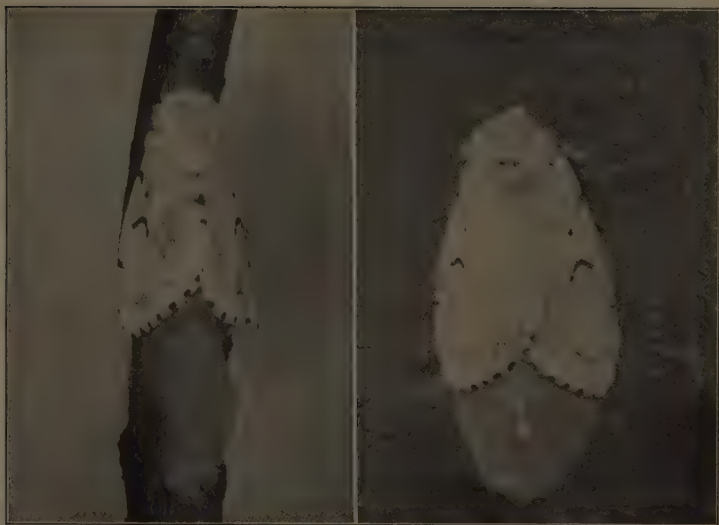


BANDED ORCHARD, AND WORKMAN EXAMINING A BAND TO DESTROY
GYPSY CATERpillARS.

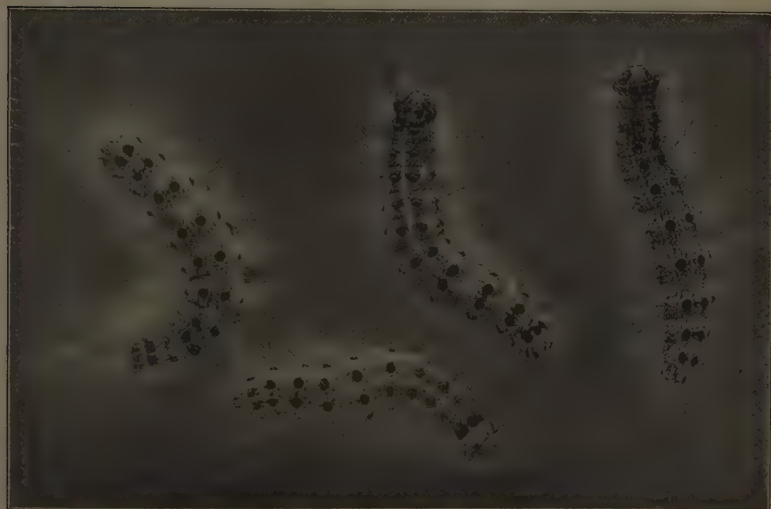


GYPSY MOTH WORK: APPLE TREE BEFORE AND AFTER PRUNING,
SCRAPING AND FILLING CAVITIES.



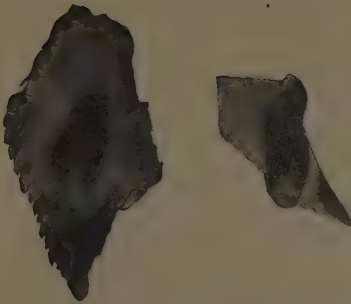


a.—Female moths laying eggs on bark. Natural size.

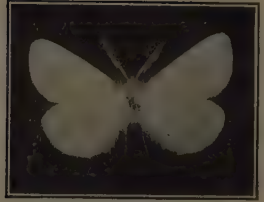


b.—Caterpillars photographed with black background.

GYPSY MOTHS, CATERPILLARS AND EGG-MASSSES.



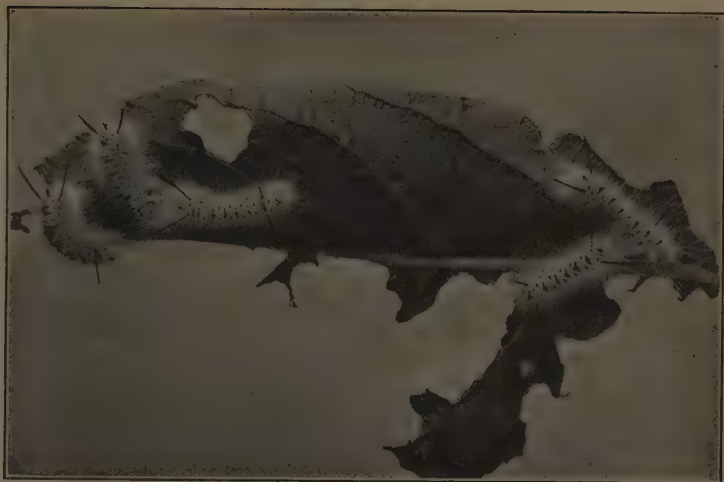
a.—Egg-masses on leaves. Natural size.



b.—Adult. Natural size.



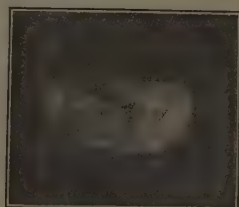
c.—Winter nests. Natural size.



a.—Penultimate stage of caterpillars. Natural size.



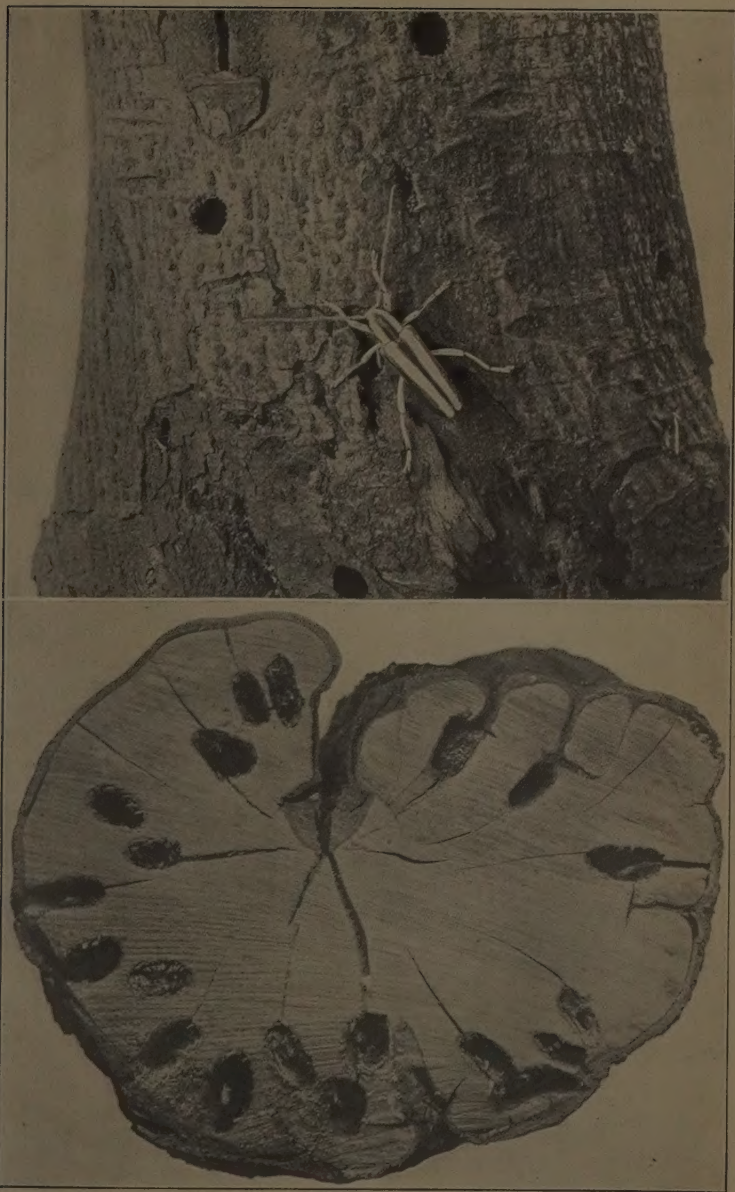
b.—Fully-grown caterpillar on leaf. Natural size.



c.—Cocoon. Natural size.



d.—Adult. Natural size.



THE ROUND-HEADED APPLE BORER AND ITS WORK. ALL NATURAL SIZE.



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